# Deep Space Products TEMP-est Systems

## Active Cooling-Fan Systems for Celestron EdgeHD and Other Fastar Optical Tubes

By Wade Van Arsdale

### The Cooling Challenge

The Schmidt-Cassegrain (SCT) telescope design offers a very cost-effective way to have a large-aperture instrument that does a good job for both visual astronomy and astrophotography. When the optical elements are properly aligned and the optical tube assembly (OTA) is thermally equalized, this design can provide excellent performance for both high-resolution planetary and general deep-sky use.

One of the problems presented by this closed-tube design, though, is that of thermal issues inherent to the mass of the fully enclosed aluminum tube and glass elements, and the soft, poorly defined focus this can cause, an issue that is often mistakenly assigned to the build or optical quality of the telescope.

Especially for aluminum OTAs, the tube wall cools at a rate that can vary widely from that of the primary-mirror glass, and this unequal cooling rate is exaggerated with fast-dropping outdoor ambient temperatures. This unequal cooling of the two surfaces promotes air currents inside the tube and a boundary layer to form between warmer air at the primary mirror's front glass surface and colder air inside the tube, which combines to temporarily but significantly degrade the performance of the telescope. Typically, the larger the telescope's aperture, the greater this difference in cooling rates becomes and the worse the impact on optical performance until temperatures equalize within the OTA. When done passively by simply letting the tube and glass cool down on their own, this equalization process can take 2 to 3 hours, or more. On the largest apertures, the OTA components may never completely equalize with continuously dropping ambient temperatures.

Image 1 – Celestron EdgeHD optical tube showing TEMP-est rear-collar fans (available in multiple colors, including black).

Deep Space Products (www.deepspaceproducts.com) supplies carbon-fiber replacement tubes that work to match the cooling rates of the primary mirror glass. When these two cooling rates converge much closer together, the internal air currents and glass boundary layer problems can be lessened greatly, and a much more stable and higher-quality view can be obtained from the telescope if the sky conditions overhead are good.

Despite the advantageous thermal properties of carbon fiber, you still need a way to get the entire telescope cooled down and equalized as quickly as possible. Quick equalization becomes even more important for mobile observers or imagers who may have limited time for observing and imaging due to the competing time demands of travel to the remote site and setup. But compared to carbon-fiber tubes, aluminum tubes are a greater challenge to keep equalized throughout the night given the fast-dropping temperatures that often accompany otherwise favorable viewing and imaging conditions. You can wait it

Image 2 – Front TEMP-est Fan, mounted in Fastar cell with power cable attached.

Image 3 – Rear TEMP-est fans in black, mounted on a Celestron CPC Deluxe 1100-HD

out another couple of hours until the tube is better equalized before you begin, or even use an aftermarket fan like the Lymax Cat Cooler on standard SCT's, only to have your observing session ruined later on in the night as ambient temps continue to drop and the thermals inside the tube re-form once again as "runaway cooling" of the aluminum tube wall sets in.

The new Celestron EdgeHD telescopes present an additional challenge. The standard Celestron SCT design has an open baffle tube which allows the quick insertion of a Lymax Cat Cooler or similar fan from the rear of the tube to rapidly equalize the OTA. But on the newer Celestron EdgeHD OTAs, the baffle tube is sealed with a permanently mounted corrector lens set, so you can't use a rear baffle-tube cooler at all on

EdgeHD tubes.

The new passive rear-vent design of the EdgeHD OTAs helps speed equalization, but an even more effective solution is still needed to get and keep the tube thermally stable throughout the night.

## Enter the DSP TEMP-est Systems

Ed Thomas of Deep Space Products has devised some very clever active cooling-fan options under the TEMP-est TEMPerature Equilibration System banner, with options that include both front and rear cooling fans designed to not only get the OTA stabilized rapidly prior to observing, but also to keep it stable all through the night regardless of how fast the ambient temperatures are dropping.

For Fastar-ready telescopes, you begin prior to observing or imaging with a fast <30-minute cool-down from the front of the OTA through the Fastar secondary-mirror mount, as shown in **Image 2**.

The Celestron EdgeHD and selected CGE Pro-XLT non-Edge optical tubes have a removable front Fastar assembly. The Temp-est front fan makes use of this by temporarily replacing the secondary mirror with a front high-flow fan prior to observing. The fan inserts easily into the Fastar cell and is held securely in place by the original Fastar threaded retaining ring, while the secondary mirror is safely stored during the initial cool-down period. After initial cool-down is complete, the front fan is removed and the secondary mirror is replaced back into the Fastar cell. The secondary mirror assembly has a locator pin on the side of its housing that causes the secondary to always be reinserted to exactly the same position every time. I tested this several times by checking collimation at high-resolution with a webcam star-test display on-screen, and, after several cycles of insertion and reinsertion of the secondary mirror, I could not detect any changes in the telescope's optical collimation. So, this method of fan placement in the front seems very robust, easy to do, and mechanically reliable.

Perhaps even more important is that Ed has also devised a rear fan solution as part of his TEMP-est System cooling options (see **Image 3**). The rear fans make use of the factory-installed vents along the side edge of the rear collar of the Celestron EdgeHD and selected CGE Pro-XLT OTAs.

The front and rear fans both run on simple 12-volt DC power supplies with your choice of fan power port to fit either a 2.5-mm or 2.1-mm tip diameter. I use part number "PS-12" (**Image 4**) from ScopeStuff.com (2.5-mm tip) to power the fans, and this power supply has shown excellent reliability.

The power supply is well regulated, has plenty of reserve power, is small in size, lightweight and easy to pack to remote sites, and is sealed to protect it from environmental moisture and humidity.

**Image 4 – ScopeStuff.com "PS-12" power supply.**

To install the rear fans, the factory vent covers are unscrewed and removed from the OTA, then the fan assembly is placed into the factory holes. The only installation tool you need is a simple Phillips-head screwdriver. The TEMP-est rear fans come preassembled from the factory with the vent covers already installed on the fans and a filter screen in place to reduce any intrusion of dust into the interior of the OTA. There is a small

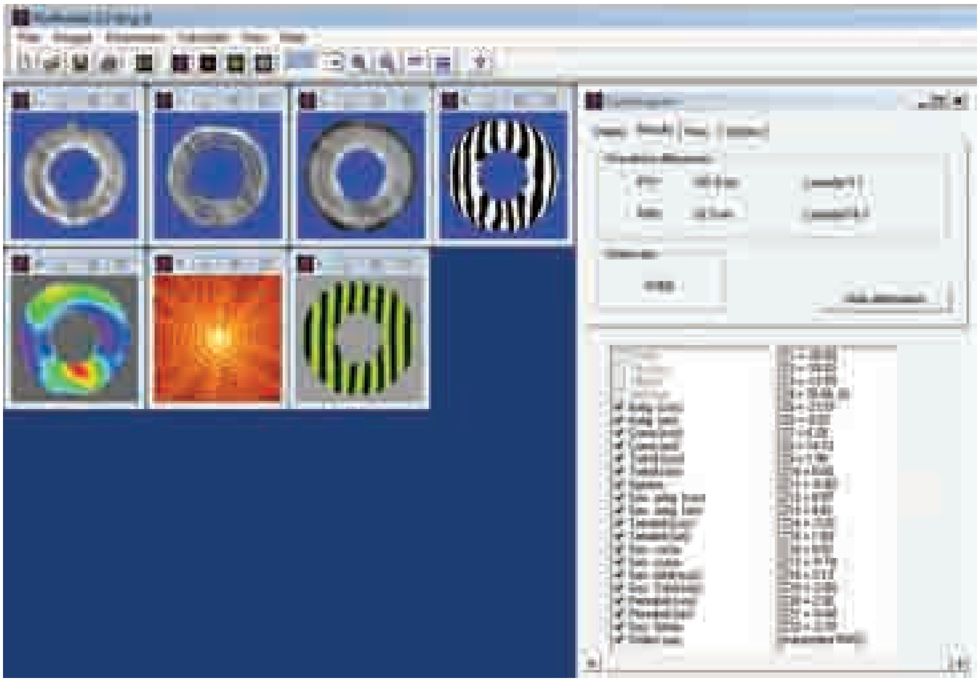

**Image 5 – Before fans: a mediocre 0.87 Strehl after 30-minute passive cool-down without fans.**

wire pre-installed to interconnect the two fans so you can run them both more easily from just one power supply. The wire stays out of view inside the optical tube and is easily routed internally from one vent hole to the opposite side of the OTA. Once you have connected the two fans together with this wire, you are ready to use both.

Ed's rear-fan system makes effective use of the multiple factory vent holes of the tube. On most EdgeHD standalone tubes, there are two vent holes, which allow the TEMP-est System to use a "push-pull" strategy with the fans: one fan pushes outside air into the tube, and the other fan pulls it back out the other side of the tube. The resulting cross-flow keeps the air routed properly behind the primary mirror to prevent exaggeration of air currents in front of the mirror and in the light cone. It also helps set up a gradient inside the tube that helps route any residual heat from the primary mirror glass out of the tube and also helps draw warmer air from inside the tube to the outside. This air flow in the back helps keep the temperature of the glass surfaces equalized with the internal air temperature, reduces internal air currents and any boundary layer in front of the primary mirror surface and stabilizes the wavefront. On nights of fast-dropping temperatures, the rear fans can be run intermittently anytime you see the view starting to degrade from the reformation of internal tube thermals.

On the Celestron CPC Deluxe HD 11-inch fork-mount telescopes, the OTAs have three factory vent holes instead of two. For this application, I asked Ed to make two "pull-only" fans and left the third factory vent as-is with no fan, leaving it for use as the air intake. This configuration proved to be very effective in improving the wavefront quality when I Strehl-tested the OTA.

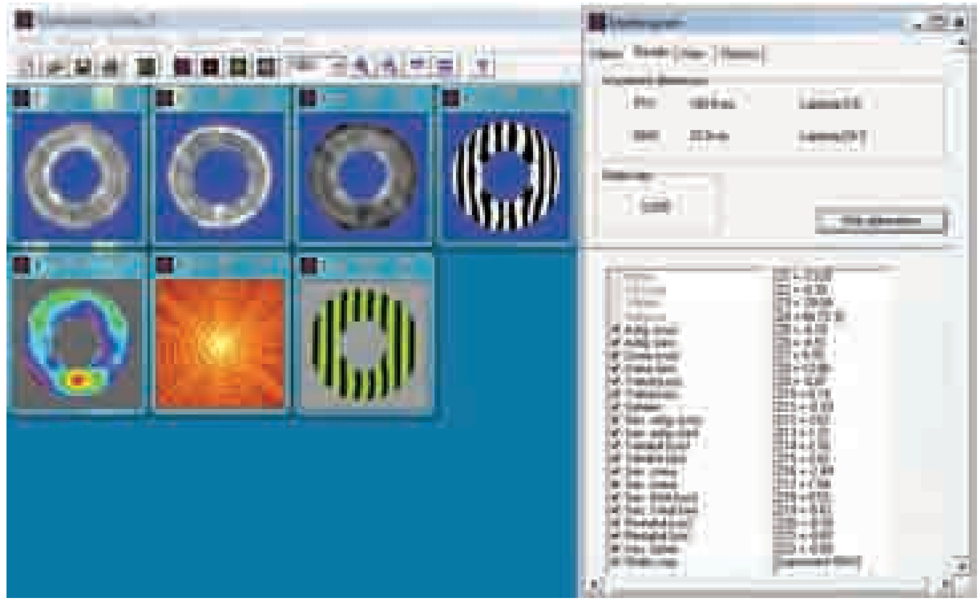

**Image 6 – After front fan: wavefront Strehl has jumped from 0.87 to 0.94 after 30 minutes of the front fan!**

### Testing the Effectiveness of the TEMP-est Systems

For the initial testing of the TEMP-est System, I used a Celestron CPC Deluxe 1100HD OTA with a combination of TEMP-est rear fans and another brand of front fan. I wanted to see visually at the eyepiece if I could detect any differences in quality of view. I observed Jupiter near the meridian with no artificial cooling of any kind after allowing a 30-minute passive cool-down. The initial views after this passive cool-down were typical of un-cooled SCTs: soft, "mushy" focus with lots of "swim" in the eyepiece. I then installed and ran the front fan for 30 minutes and re-observed Jupiter. The view was remarkably more stable at 215x magnification at the eyepiece after the front fan was used. The typical Jupiter "swim" in the eyepiece was reduced from a slow-rolling "wave" effect that distorted the entire planet and ruined focus, down to a fast-cycling, very slight "ripple" effect that could only be detected at the limb edges of the planet and did not hurt surface contrast or focus at all. This slight ripple effect was likely due to the sky atmospherics and was not coming from the OTA itself.

But an hour after using the front fan I noticed that the image quality had degraded again once the runaway cooling of the aluminum tube surface had taken hold. It was a cold night for this test, with fast-dropping temps ranging from the 40s down into the 20s. At this point, I began running the Temp-est rear collar fans to see what effect this had on the view. Again, the change was remarkable. After about 30 seconds, the view started to return to the slight fast-cycling ripple effect. Within about 5 minutes, the view

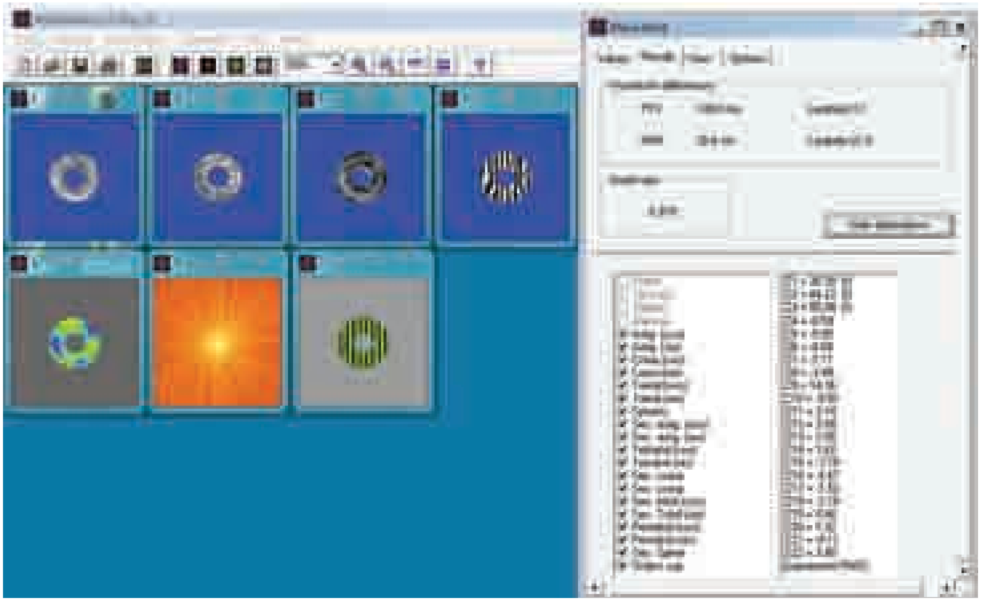

**Image 7 – Before fans: 0.92 Strehl performance after a 1-hour passive cool-down with no fans in use.**

had completely stabilized again. I repeated this test for a total of three cycles, and the results were the same every time at the eyepiece.

The combination of initial front fan at the beginning of the evening followed up by intermittent running of the rear fans through the night seemed to make a significant and unmistakable improvement in the eyepiece views.

An important factor I observed with the rear fans is that, even at high-magnification, I could detect no additional vibration in Jupiter's image with the rear fans on versus off. The "MagLev" rear fans Ed uses in his TEMP-est rear fan system are very quiet and free of vibration. This is crucial to allowing you to run the rear fans while observing. The MagLev design allows for very good flow rates without the vibration that is present on larger, standard-sleeve or ball-bearing fan designs. The rear fans are so quiet that you have to think about it and listen for them to actually hear them. The rear fan sound just "disappears" when in use and is not noticed at all.

For the next phase of tests, I wanted to test quantitatively what I thought I was seeing at the eyepiece. I used Mark Crossley's English version of the *Astro-Surf Roddier* software to Strehl-test the 11-inch telescope before and after cooling. The reference wavelength in all results below was the standard Green at approximately 550-nm wavelength. As shown in **Image 5**, 30 minutes of passive cooling brought the scope only to a mediocre Strehl of 0.87. But, as shown in **Image 6**, 30 minutes of active cooling using the front-mounted fan improved performance to a much better Strehl of 0.94.

Later Strehl tests on a Celestron C14EdgeHD OTA with the complete TEMP-est System fans, front and back, showed similar improvements in wavefront quality. Before running either the front or rear fans and after a full 1-hour passive cool-down, performance was measured at 0.92 Strehl (**Image 7**). After 30 minutes of running the front and rear TEMP-est System fans, the telescope was brought to an outstanding 0.97 Strehl (**Image 8**).

## Test Summary

I used a combination of home-made front fan, another brand of commercially-available front fan, and the TEMP-est front fan for the CPC EdgeHD 11 and C14 EdgeHD tests, with no significant difference in results between the three front fans, but only the TEMP-est System fans were used in tests of rear-mounted fans on both OTAs.

The wavefront improvement from the TEMP-est System fans was very evident in the testing and confirmed what I was seeing at the eyepiece. A jump in Strehl from 0.868 to 0.935 was measured on the fork-mount Celestron Edge OTA after using the front and rear fans. This compared to a jump in Strehl of (0.919 to 0.967) on the C14 EdgeHD OTA after using the complete TEMP-est front and rear fan system. This is a significant and consistent improvement in wavefront quality that can also be readily detected at the eyepiece during high-resolution planetary observation or planetary webcamming.

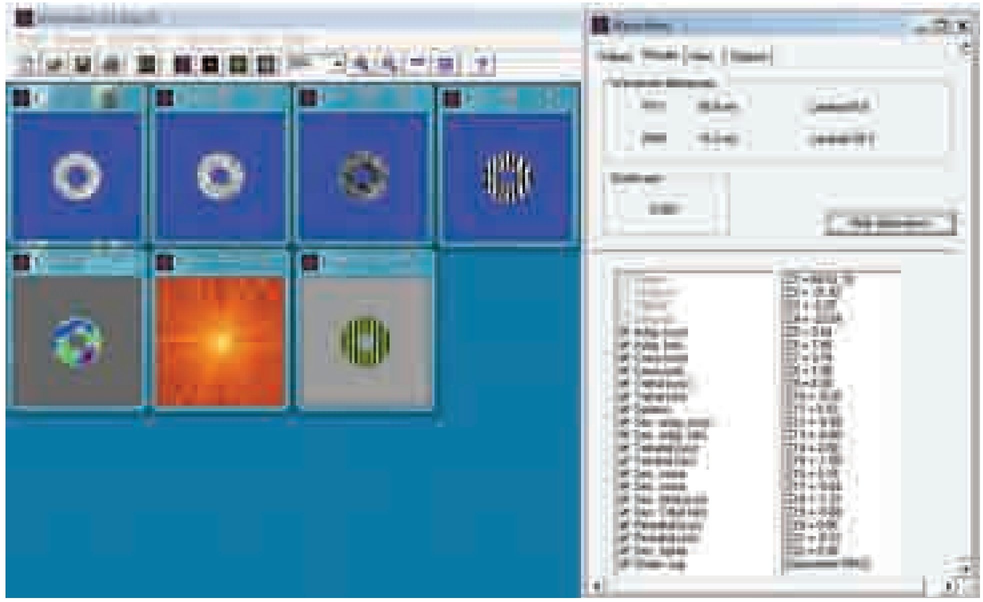

**Image 8 – After 30 minutes of TEMP-est System front and rear fans, there was significant wavefront improvement to an outstanding 0.97 Strehl.**

In several further test cycles that followed, the range in Strehl improvement ran from 0.01 Strehl to 0.04 Strehl for the C14 EdgeHD that was by then being housed in an observatory where cool days meant smaller ambient temperature changes. For mobile setups where the CPC Deluxe HD11 rig was coming from a warm inside-car temperature to much colder ambient outdoor temperatures, the Strehl improvement was much greater across all test cycles, ranging from 0.04 to 0.07 improvement in Strehl once the front fan and TEMP-est System rear fans were used.

I suspect that for any situation where you have a large temperature gradient, either with a hot OTA in a closed observatory or transporting from a warm car to cool outdoor temperatures (or transferring an automobile air conditioning-chilled OTA to hot outdoor temperatures), the Temp-est fans would have a much more pronounced effect on improving performance than on nights with very little temperature gradient present between OTA and outside air.

**Image 9** is a test shot of Jupiter captured using the CPC Deluxe 1100HD fork-mounted telescope and a planetary webcam while the TEMP-est System rear fans were running. The crisp detail is testimony to the vibration-free performance of the fans, as well as to their positive effect on internal tube temperature gradients or boundaries.

**Image 10** shows another test shot, this time of Mars, which image was made through the C14 EdgeHD OTA. Unfortunately, Mars was showing its more barren side toward Earth on the evening of the tests, but the excellent performance of the telescope when thermally equalized and under good atmospheric seeing is again as evident as it was with the CPC Edge 11 inch OTA.

## Conclusions

The visual and wavefront testing I ran on my two Celestron EdgeHD telescopes showed consistent improvement

**Image 9 – This test image of Jupiter was captured with a planetary webcam and the CPC Deluxe 1100HD fork-mounted telescope while the TEMP-est System rear fans were running.**

**Image 10 – This test image of Mars was taken with the TEMP-est System equipped C14 EdgeHD OTA.**

in optical performance from using Deep Space Products' TEMP-est System front and rear fans. The tests clearly indicated that the TEMP-est System is a very effective and easy-to-install solution that can significantly improve the wavefront performance of Celestron EdgeHD and CGE Pro-Fastar telescopes anytime you have a large temperature gradient present between the OTA and outside temperatures.

The TEMP-est System front and rear fans can help stabilize the thermal equilibrium of these telescopes and then keep them stable throughout the night as temperatures continue to drop. When good overhead sky atmospherics are combined with the TEMP-est System fans and good optical collimation, these telescopes can be made to perform at a high level for serious high-resolution planetary work. You no longer have to be limited to mostly deep-sky, low-magnification work for high-quality views. Note: Deep Space Products also offers rear SCT cooling fans for non-EdgeHD telescopes and other SCT OTAs that are not factory equipped with rear side-collar vents. ATT