

## Dutch Open Telescope: Status and Prospects

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**Abstract.** The Dutch Open Telescope represents a new solar telescope concept. Being open rather than evacuated, it leads the way to large-aperture high resolution telescopes. It is now being installed on La Palma.

### 1. Introduction

The Dutch Open Telescope (DOT) has arrived on at La Palma. Its presence alters the Roque de los Muchachos skyline — as if a Martian invader out of the *The War of the Worlds* has descended on the mountain (Fig. 1).

The DOT structure is novel to astronomy. The telescope and the support tower are both open and there is no dome, only a fold-away bad-weather canopy. At La Palma, the best daytime seeing tends to occur when strong winds from Northern directions suppress the convective plumes that arise from local ground heating. The DOT's principle is to minimize obstruction to the local air flow and to rely on the same winds, blowing right through the telescope, to inhibit convective turbulence within the telescope and in its immediate surroundings.

The open design of the DOT departs radically from existing solar telescopes. All current high-resolution telescopes rely on internal evacuation to avoid internal turbulence. For these, the vacuum window (in reflectors such as the NSO 76 cm VTT at Sacramento Peak, the German 70 cm VTT at Tenerife, and the French-Italian 90 cm THEMIS at Tenerife) or the objective lens (in refractors as the Swedish 47 cm SVST on La Palma) set a restrictive size limit. The LEST design (250 cm) therefore relied on helium filling, while the current design for CLEAR (200–400 cm) has an enclosing shroud rather than a closed tube. Thus, the DOT represents an important test for large-telescope concepts. If the open principle works satisfactorily, it may be the way to grow. Also for the DOT itself. The current DOT aperture is 45 cm, but the mechanical structure accepts an 80 cm mirror without change and a yet larger one with only minor modification.



Figure 1. The DOT on La Palma, October 1996. The upper picture shows the skyline from the Roque de los Muchachos, looking down towards the East. From left to right: William Herschel Telescope, Dutch Open Telescope, Swedish Vacuum Solar Telescope, Isaac Newton Telescope and Jacobus Kapteyn Telescope. The lower picture was taken from the Caldeira rim trail. The DOT will be operated from the SVST (the square building and tower at right).

## 2. DOT history

It is fitting to add a bit of history at this JOSO meeting because the DOT originates from JOSO at its heydays. JOSO had three major goals, namely the selection of the best site in Europe, the installation of national telescopes at that site, and the realization of a large European facility there. The site-test scheme aimed to first narrow down the choice using proxies such as temperature fluctuation data, then compare the left-over candidate sites using medium-size telescopes. That schedule led C. Zwaan, who played an active role in the JOSO

site testing, to initiate the “open tower telescope” project at Utrecht. He proposed to R.H. Hammerschlag to design and build a transportable open telescope that would minimize disturbance to the local air flow.

Now, two decades later, the Utrecht Open Telescope is nearly complete. Along the way, it evolved from a site-test instrument to a research-oriented facility. It now represents, just as THEMIS, a JOSO Phase II activity (with Phase III, LEST, ever yet below the horizon). It has been renamed into “Dutch Open Telescope” in a ceremony last June because it is the first fully Dutch telescope on La Palma and as such should make Holland a formal member of the Roque de los Muchachos consortium — awaiting that, the DOT is erected on La Palma under the benevolent patronage of the IAC. The project enjoys local hospitality at the Swedish SVST building, from which the DOT will be operated.

The construction of the DOT has followed the slow pace of much larger projects such as THEMIS for two reasons. First, the project has essentially been a one-man show (Hammerschlag) that had to rely on university workshop goodwill at Utrecht and Delft and on tight university funding. Second, the requirement that the telescope must point stably while being buffeted by strong winds has led to much time-consuming emphasis on mechanical stability. Eventually, the innovative telescope drives that Hammerschlag developed to reach unprecedented pointing stability led the Dutch foundation for technology (STW) to fund the DOT completion. STW also funds the current installation of the DOT on La Palma, in order to verify whether the telescope, drives and support tower perform to specification.

### 3. DOT design

The DOT is a reflector with a parabolic mirror that sits out in the open at a height of 15 m. The mirror (currently Cervit, 45 cm diameter, focal length 200 cm, peak-to-peak surface quality better than  $\lambda/10$ , rms better than  $\lambda/50$ ) focuses the incoming beam onto a water-cooled diaphragm that reflects most of the image out of the telescope and transmits only a  $2 \times 2$  arcmin subfield. Initially, the latter will be recorded with a video CCD through a 1 nm G-band ( $\lambda = 430.5$  nm) filter using relay optics including a microscope objective to obtain pixels of 0.1 arcsec. The video signal is transported per optical link to the SVST building.

The mirror is mounted deformation-free with nine-point axial and three-point radial support in a parallactic telescope structure that is considerably overdimensioned as well as unbalanced in order to obtain extreme pointing stability at very low dissipation. The latter amounts to only about 20 W, three orders of magnitude less than the heat production of the oil bearings in the nearby Wiliam Herschel Telescope. Brushless pairs of servo motors in push-pull preload configuration without backlash drive 4-step gear trains achieving 1:75,000 reduction with self-aligning gears.

The 15 m high support tower, at 13 tons considerably lighter than the telescope itself, permits only lateral motion of the platform. It consists of open steel-tube triangles and is designed to withstand large ice loads and wind pressure — the ladder and elevator cage may fill up with 30 tons of ice.

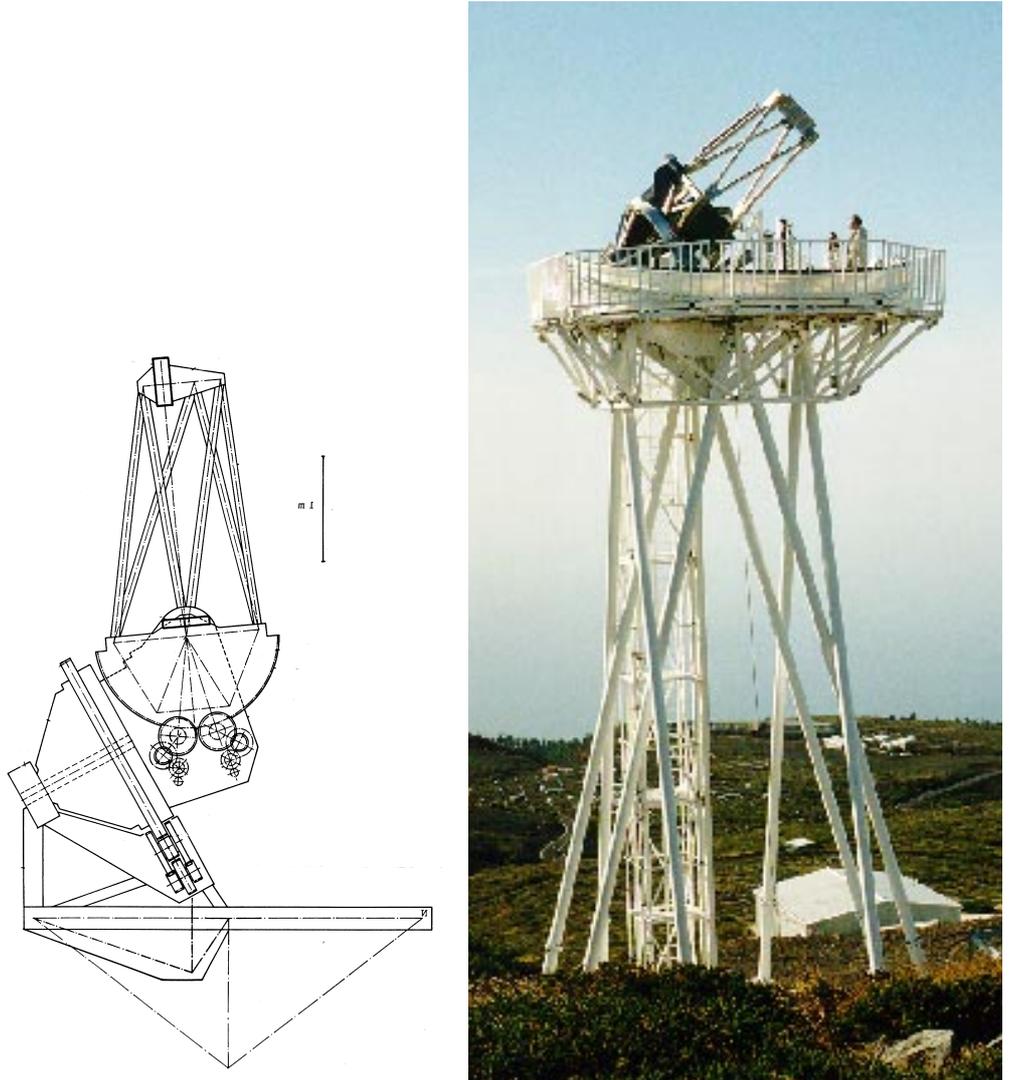


Figure 2. Left: sketch of the DOT pointing at the sun from La Palma at noon on June 21. The bar measures 1 m. Right: The DOT on its tower, La Palma, October 1996. North is to the right.

The bad-weather enclosure opens clam-like and folds away to the sides. It is made of heavy polyester fabric mounted on steel ribs and may be closed in winds up to 30 m/s (or opened, but that is less likely). When closed it should withstand the 70 m/s (Bf 12) winds that occasionally hit Roque de los Muchachos.

#### 4. DOT status

The tower, platform, telescope and enclosure have been mounted on the La Palma site during the past summer. The telescope drives and drive controls

(located in the SVST building) function properly. First light and first images are expected in the spring of 1997. Air-suction experiments, near the prime-focus diaphragm and elsewhere within the open telescope structure and combined with schlieren tests, are planned in order to optimize the internal heat budget.

The final verification test of the open principle will consist of a real-time image quality comparison with the SVST. The telescopes are similar in having a 45–47 cm aperture and in offering their imaging element as first piece of optics to incoming solar photons. In the case of the SVST, that is the doublet lens; in the DOT, the parabolic mirror. Thus, the two telescopes represent basic extremes of the refractor and reflector concepts, respectively. It is exciting to compare these at one site.

Financially, the status of the DOT is insecure. As mentioned, STW funds the DOT installation and verification for technological reasons. After that, funding must be science-oriented. Given the current climate in Holland, where solar physics is presently much smaller than during the De Jager era, cornering funding will be an uphill fight. Clearly, the DOT must perform outstandingly well. It is no exaggeration to state that the future of Dutch solar physics rides on the open telescope principle.

## 5. DOT science

In its initial configuration, the DOT is an imager aiming at high-resolution monitoring of the Muller bright points seen in the G band when the seeing is superb. They mark intergranular flux concentrations. Our goal is to trace them as markers of the magnetic field in connection with similar magnetic-patterning studies using SOHO's MDI at lower resolution, in close collaboration with the Lockheed group.

On a longer time scale the DOT should employ multi-channel imaging, including  $H\alpha$  using the Ottawa River Solar Observatory filter that we have on loan. We also aim to use the image restoration techniques pioneered at the SVST. The SVST, with its versatile laboratories at the bottom of the refractor, is more suited to trying out new techniques than the DOT which requires robust post-focus instrumentation. The DOT, offering stable pointing without field rotation, is well suited to follow-up of new developments at the SVST in larger-volume applications. Its use will be open to the whole solar physics community.

Future expansions that we envisage include the installation of a larger mirror, of a Cacciani magneto-optic magnetograph in collaboration with our Italian colleagues, and of a 2D spectrometer that uses fibers to reformat a square input field into a linear slit. You are welcome to share in these developments.

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