ChroTel: a new robotic solar telescope

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A recently built telescope on Tenerife will observe eruptive events in the solar chromosphere and help to gain physical insights into the underlying triggering mechanisms.

The chromosphere is a thin dynamic layer in the solar atmosphere, located between the surface and the corona. It is not visible to the naked eye, except for a few seconds during a total eclipse. The spectacular and energetic processes occurring here can be visualized using narrow-band optical filters. For better insights into the as yet poorly understood physical mechanisms causing these chromospheric events, continuous high-quality observations are required. Some of these phenomena are very short lived and highly unpredictable.

ChroTel, a new solar telescope nearing completion at the Teide Observatory on Tenerife, Spain (see Figure 1), allows near-simultaneous observations of three different solar chromospheric layers. This is achieved by recording narrow-band images at different wavelengths, employing a short cadence of about a minute. The potential combination of this imaging capability with coordinated spectroscopic observations using the existing nearby high-resolution solar telescope will lead to the establishment of a unique astronomical facility. The images will reveal information about the highly energetic physical processes and their signatures in the chromosphere. The onset, evolution, and dissolution of eruptive events such as prominences, flares, and coronal mass ejections can be examined throughout almost the entire chromospheric altitude range, thus allowing us to uniquely determine the associated plasma motions.

ChroTel’s main scientific objectives include measuring the dynamic response of the solar chromosphere to photospheric driving of the ejections. Models predict that magnetoconvection at the solar surface can lead to convective collapse, which causes chromospheric plasma to rapidly accelerate toward lower altitudes. Chromospheric Doppler-shift observations of the full solar disk will provide the spatial coverage required to further investigate the physical conditions associated with these processes.

Second, ChroTel will probe large-scale structures in the solar chromosphere, in particular plasma-flow behavior during and after eruptions. Hα filtergrams will provide unique opportunities to investigate the relevant Doppler shifts. The telescope’s full-disk coverage will ensure that all events are recorded.

Third, the telescope will enable studies of the fast solar wind. Close examination of the Doppler shifts associated with the Hα absorption line may show the signatures of solar-wind outflows deep inside the chromosphere. If so, this will help to clarify whether the solar wind is injected deep in the chromosphere, forming a continuous flow away from the sun, or at higher levels in the transition region to the corona.

The new facility (see Figure 2) is a refractor with an effective aperture of 100mm and a focal length of 2250mm. Its mechanical design is a robotically operated domeless fully encapsulated turret system. The domeless construction was one major reason for the use of a turret. All drives, optics, and light paths are located inside the protective housing but accessible for maintenance. A motor-driven shutter that will open only during observations protects the entrance window.

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ChroTel uses a three-stage guiding and pointing system. First, the sun’s position is computed from the local time. This calibrates the telescope drives to the correct speed for proper guiding. Second, a slow-guider system detects deviations from the nominal solar position and sends the requisite correction signals to the motor drives. Third, a servo system using a limb sensor and a piezo-driven tip-tilt mirror measures and corrects for fast image motion. This leads to an overall pointing precision of better than 0.5 arcseconds.

The focal-plane instrumentation consists of three narrow-band Lyot-type filters for wavelengths around 393nm (a resonance line of ionized calcium), 656nm (the neutral hydrogen-α line), and 1083nm (a neutral helium line). The first two filters have fixed throughputs and bandwidths of 0.03 and 0.05nm, respectively. The helium filter was rebuilt—based on an existing fixed-wavelength Lyot filter—as a tunable filter with a step width of 0.014nm. This allows measuring the solar-plasma motion via Doppler shifts of the helium line.

The sun is imaged onto a CCD with 2048 × 2048 pixels, with a pixel scale of about 1 arcsecond. The telescope’s field of view is 0.6°, i.e., the full solar disk and about 100 arcseconds of the outer atmosphere are recorded simultaneously (see Figure 3 for an example). Operation of ChroTel will start in 2009. Synoptic images at low cadence will be made available on the Web immediately.

The full observational sequences will be stored for follow-up off-line analysis.

Ch. Bethge, D. F. Elmore, R. Friedlein, C. Halbgewachs, M. Sigwarth, and K. Streander made important contributions to the ChroTel project.

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References