The Göttingen Solar Radial Velocity Project

Monitoring Convective Motion and a New Solar Atlas

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At the Institut für Astrophysik Göttingen (IAG), we are operating a Vacuum Vertical Telescope together with a Fourier Transform Spectrograph to obtain high-precision disk-averaged and spatially resolved spectroscopy of the solar surface. We are observing the disk-integrated Sun monitoring short-cadence radial velocity variations that are caused by motions of the turbulent plasma and its suppression by magnetic regions. The observations help to understand convective flow patterns and the role of turbulence in the search for extrasolar planets. A first product is a high-precision atlas of the solar spectrum in the range 0.4 – 2.3µm at a resolving power of R ~ 800,000.

Fibre-pickup at the Vacuum Vertical Telescope

The Vacuum Vertical Telescope (Fig.1) is integrated into the physics building at the roof of our institute. It is used for high-resolution spectroscopy of the Sun. For disc-integrated observations of the Sun, we are using the two siderostat mirrors for tracking to feed light into an optical fibre just after the second plane-parallel mirror. The setup is identical to pointing the fibre in the direction of the Sun. The effective aperture of the coupling mirror is 1.2cm. The fibre feeds the light into our optics lab located two floors below the siderostat in our institute.

High-Resolution Fourier Transform Spectrograph (FTS)

We are operating a Fourier Transform Spectrograph Bruker IFS 125HR (Fig.2). The spectrograph has a maximum optical path difference of 208 cm in asymmetric mode and 50 cm in symmetric mode. Light from the Sun is fed through a parallel entrance beam that we equipped with a fibre feed. The FTS has four different detectors covering the wavelength range between 400 nm and 15 µm. The interferometer chamber has silver mirrors to enhance sensitivity at short wavelengths. For high signal-to-noise solar observations, we can choose between two settings, one from 400 to 1100nm, the second from 900 to 2300nm.

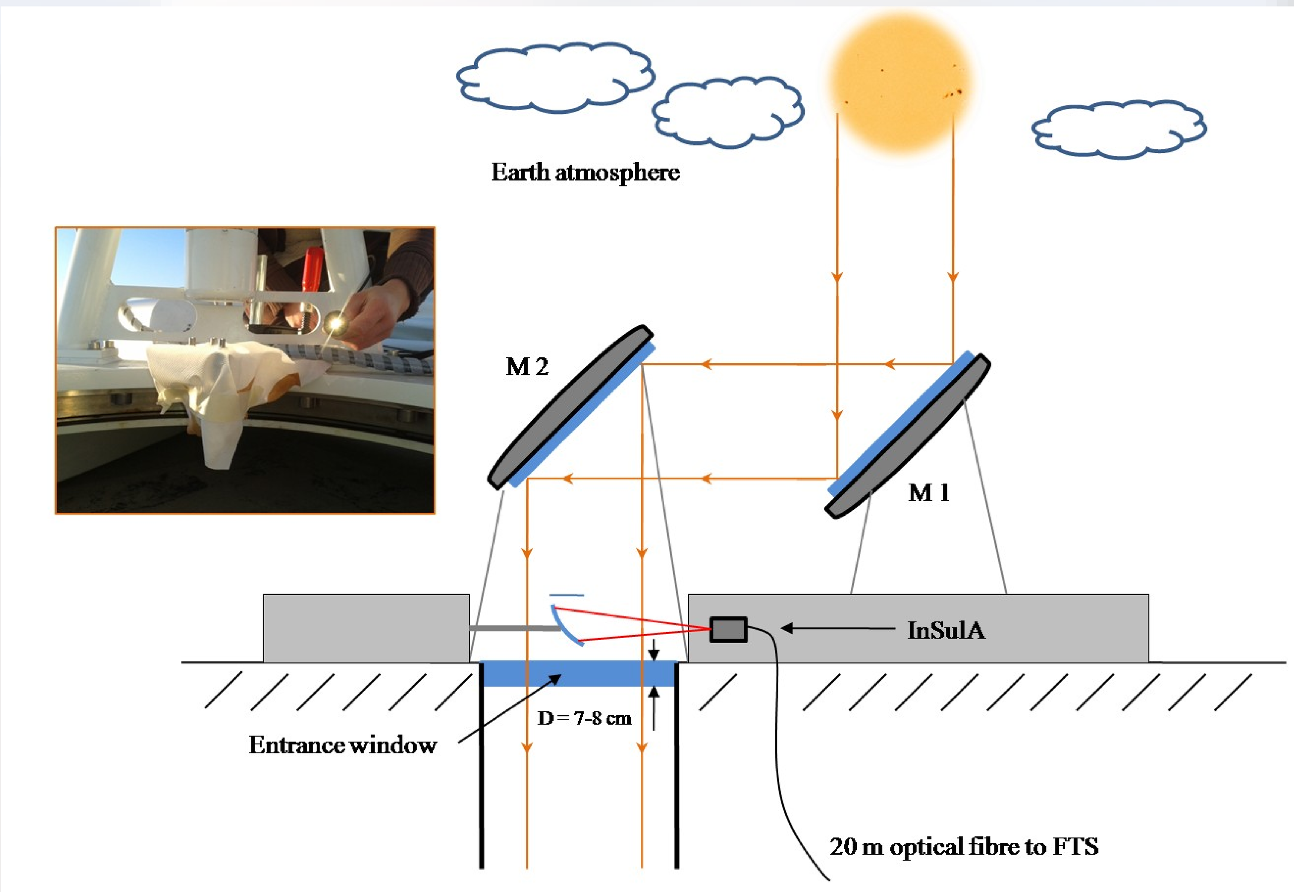
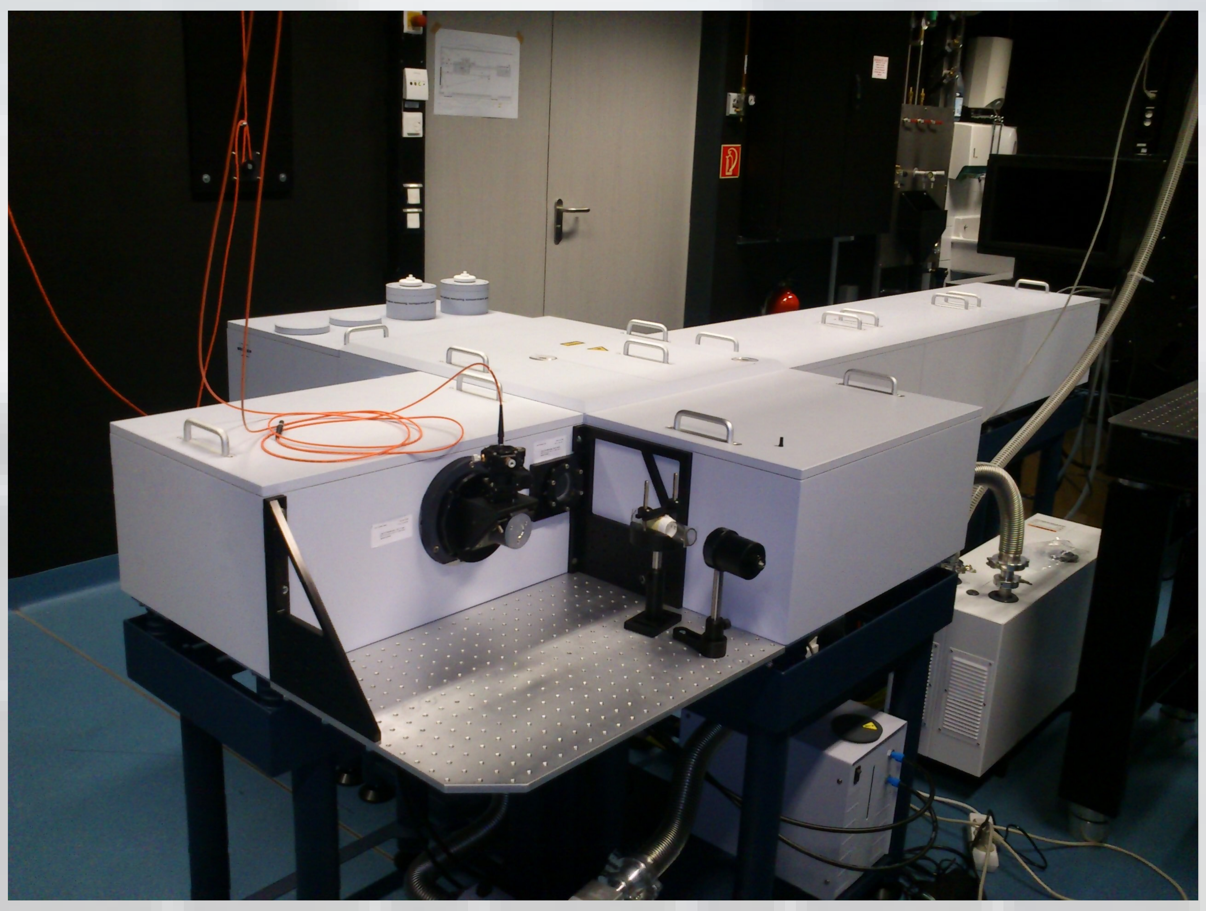


Fig.1 (left): The fibre-pickup after the two mirrors of the IAG siderostat. The aperture of the parabolic mirror that feeds the light into the fibre is 1.2cm. The two flat mirrors M1 and M2 are used for tracking only.

Fig.2 (right): The FTS in our optical laboratory. Light from the Sun is fed into the FTS via the red fibre hanging from the top.

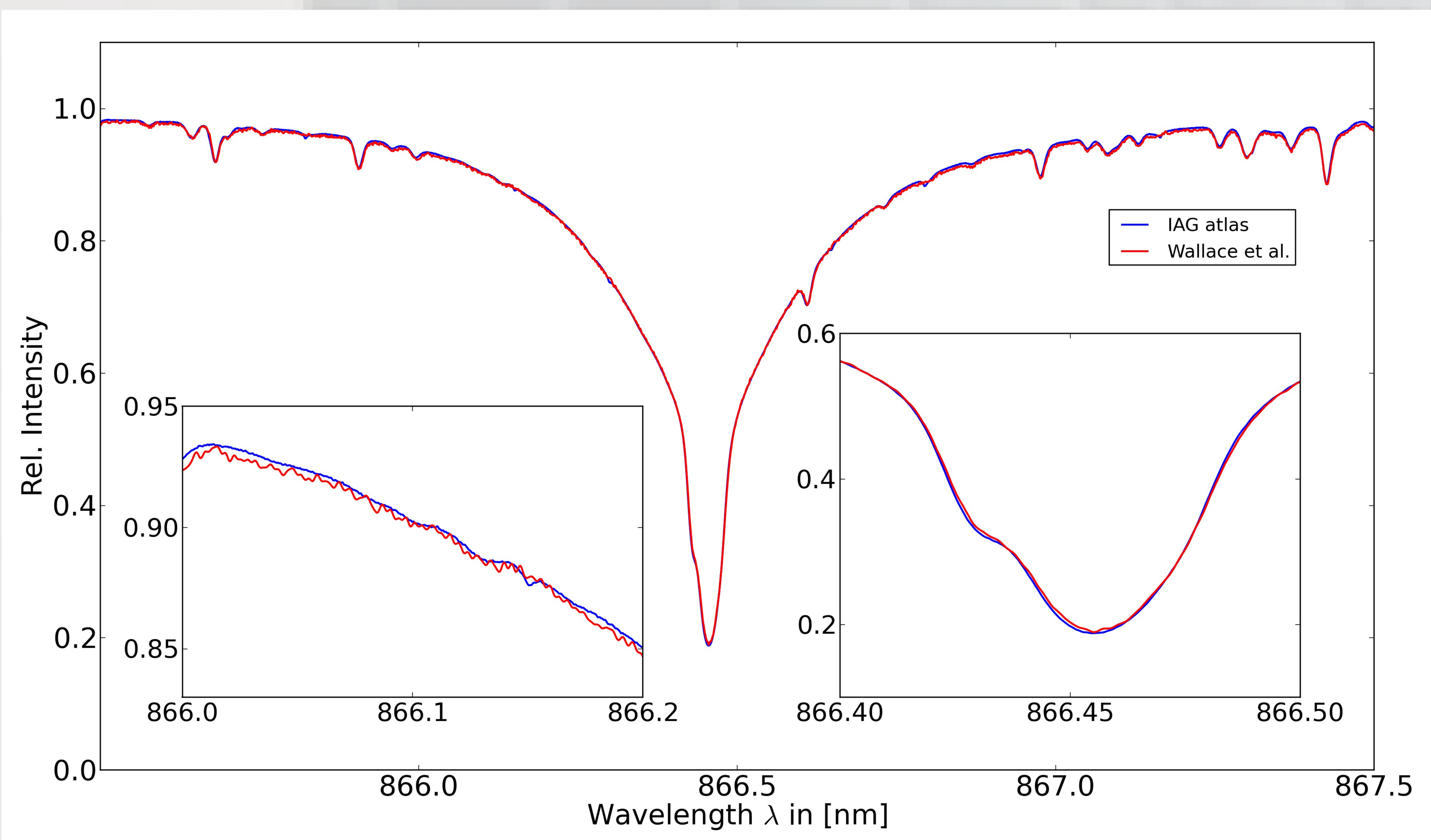


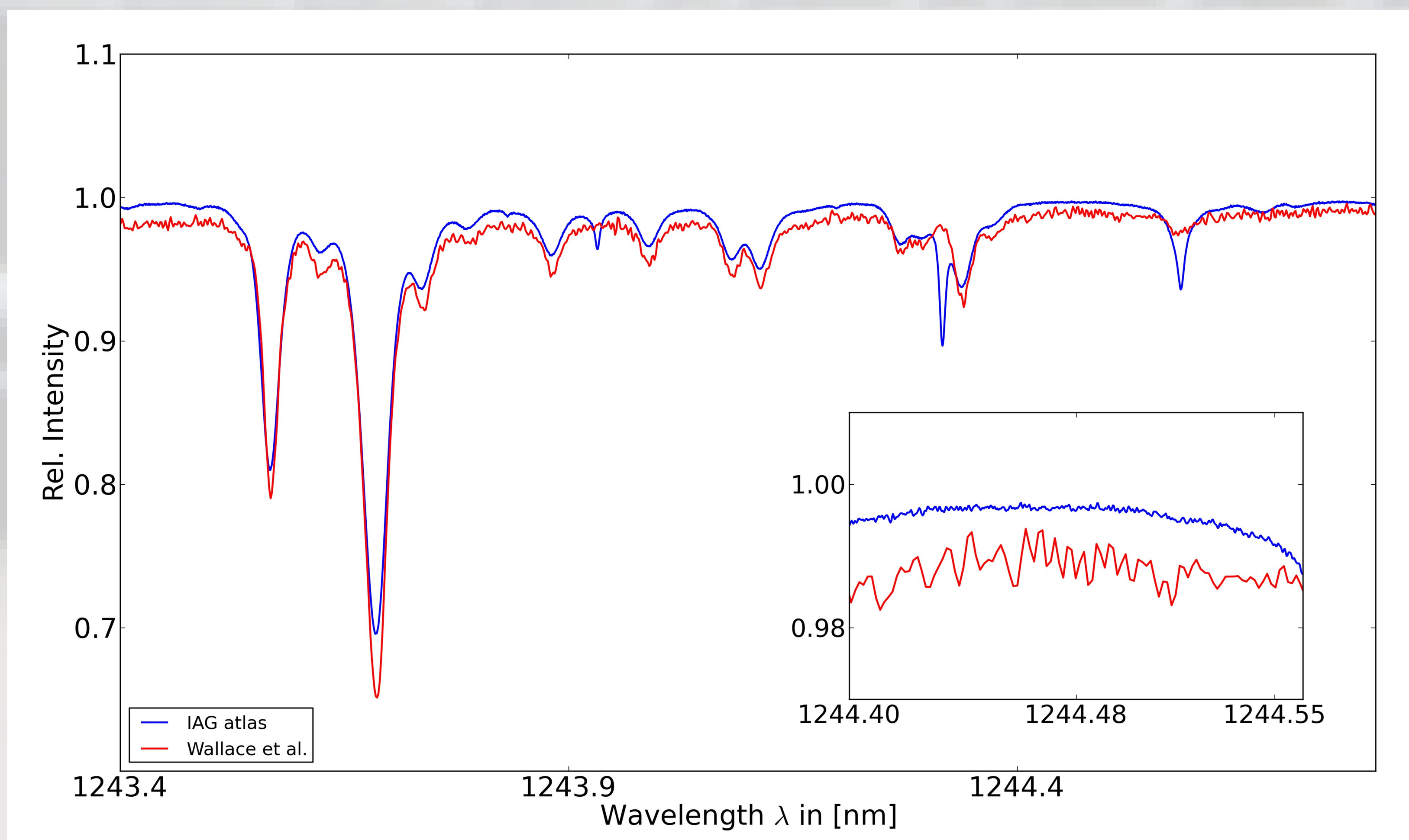
Solar Convection

We have started routine observations of disc-integrated solar radial velocities (Rvs) using an iodine cell for precise wavelength calibration. After correction for barycentric motion and differential extinction, we see RV variations on the few m/s level that are caused by granulation and solar activity. Our observations will be used to derive information on solar convective patterns and active region evolution and their influence on stellar high-precision RV observations.

A new solar atlas

We obtained a new disc-integrated solar atlas in the wavelength range 405 – 2300 nm. The data were observed in two settings. In the first setting, 405 – 1065 nm, we collected 1190 scans with our FTS, a total of 32.7 h observing time. In the second setting, 1000 – 2300 nm, 1130 scans were co-added totalling 32 h of observations. We corrected the individual scans for barycentric motion and normalized the continua. The FTS provides an intrinsic wavelength solution. From scatter between the wavelength positions in individual scans and the accuracy of our FTS calibration, we estimate an absolute accuracy of individual line positions of 27 m/s. The spectral resolving power of the new atlas is R ~ 800,000. We measure continuum signal-to-noise ratios (SNRs) of up to 6000 in some areas. Figures 3 and 4 show selected areas of the atlas in comparison with the atlas from Wallace et al. (2011) and the atlas from Delbouille et al. (1981). The line shapes are remarkably consistent and the comparisons show the high quality of our new atlas.





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