Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310010549

Extreme adaptive optics in the mid-IR: The METIS AO system

Remko Stuik[1], Laurent Jolissaint[1], Sarah Kendrew[1], Stefan Hippler[2] and Bernhard Brandl[1]

[1]Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands
email: stuik@strw.leidenuniv.nl

[2]Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany

METIS, the Mid-infrared ELT Imager and Spectrograph, is currently in its phase A study as one of the candidate first-light instruments for the European Extremely Large Telescope. METIS will feature several observational modes, ranging from diffraction limited imaging in L, M and N-bands to high-resolution Integral Field spectroscopy for the L and M-bands. METIS in its current design gives sensitivities similar to *Spitzer* in imaging and low-resolution spectroscopy and with its high-resolution spectrograph will provide unprecedented line sensitivity. The design of METIS is optimized for both galactic science cases (*e.g.* conditions in the early solar system, formation and evolution of proto-planetary disks and properties of exoplanets) and extragalactic science cases (*e.g.* the growth of Supermassive Black Holes). METIS will require a high-order adaptive optics (AO) system to meet its scientific goals, both to provide correction for atmospheric turbulence as well as reduce the impact of wind shake, leading to a residual image motion of 3 - 5 mas rms. METIS is expected to feature both an internal Single Conjugate AO system as well as an external Laser Tomography AO system. The challenges for the METIS AO system are mainly in the broad correction range, an excellent image stability required for coronagraphy and in providing a high sky coverage to be available for as many science targets as possible. An additional challenge for METIS is the need to compensate for composition turbulence, mainly in the form of fast fluctuations in water vapor concentration. Water vapor fluctuations impact the performance of METIS in several ways: Atmospheric dispersion causes a broadening of the point-spread function, both in the science channel and the wavefront channel, but can be corrected using a Atmospheric Dispersion Corrector. Variations in the water vapor composition cannot be corrected this way and are currently estimated to give a residual image motion of $\leqslant$10 mas rms. This effect can, especially for coronagraphy, not be neglected. Chromatic optical path difference errors, caused by changes in the index of refraction along the path through the atmosphere were found to be negligible in the case of METIS due to attenuation by the outer scale (at typical values of 25 m). Chromatic anisoplanatism is the effect that the light at different wavelengths travels through a slightly different light path through the atmosphere and can be– at least partly–corrected. The last effect is composition turbulence, mainly caused by fast (>1 Hz) fluctuations in the water vapor content. Based on data for ALMA and radiometer probes, this leads to a maximum loss in Strehl ratio between 5 and 10%. This mainly has an impact on coronagraphy and the METIS AO team is actively investigating ways to compensate also water vapor turbulence. The main challenge is currently obtaining reliable data on the distribution and magnitude of precipitable water vapor fluctuations.