Observing the earth beat from space with high performance optical instruments

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Abstract:

Earth observation is key to understanding earth climate, monitoring environmental emergencies and improving agricultural practices. Optical instruments are requested to provide high-resolution data of earth and its atmosphere. This translates to low noise on detectors, stable line of sight and high quality optical elements, which need to be nevertheless manufactural and easy to assemble. Furthermore, optical instruments have to cope with extreme conditions such as varying temperatures in space, radiation, zero gravity and launch loads. At the same time, mass and costs need to be ever optimized.

This talk starts with an overview of state of the art optical instrument designs for earth observation, ranging from hyperspectral imagers (e.g. Environmental Mapping and Analysis Program EnMAP) to fourier-transform spectrometers as used in the infrared sounder of the third generation of weather satellites (IRS MTG). Current challenges in optical instrument design and alignment will be exemplarily described with MTG. MTG mission houses the flexible combined imager (FCI) and the IRS. FCI will scan the earth disk and provide images for weather forecast with a resolution of up to 0.5 km. IRS will provide detailed vertical profiles of atmospheric temperature and humidity with a resolution of 4km enabling e.g. early warnings of massive thunderstorms and monitoring volcanic ash. The geo-stationary orbit of MTG allows for high frequency monitoring of earth disk, but puts challenges on instrument design such as sun intrusion. Sun intrusion is only one of many aspects influencing optical and opto-mechanical design. A short overview will be given of design drivers, which have been mastered in this program before the focus will be put on stray-light prediction and verification. Stray-light is influenced significantly by optical surface contamination and roughness and is limiting optical performance by increasing noise. Sound understanding of stray-light drivers is mandatory to optimize manufacturing processes, reliably predict and finally minimize stray-light in orbit, and hence instrument performance.

The talk will conclude with a short excursion into free-form optics. Free-form optics can help to boost optical performance and at the same time decrease volume and mass of optical instruments and hence answering the demand of higher performance instruments fitting into less space. Major challenges of this technology lie in optimization algorithms for optical design as well as developing novel manufacturing, as well as metrology and alignment methods.