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# Mechanical Integration of a Prism-Grating-Prism-Assembly for the CO2M Mission

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**Abstract.** We developed and realized a mechanical integration concept of a prism-grating-prism-assembly for the CO2M mission. The mechanical design of the mounts relies on a kinematic mounting of the optical elements. Additional, ultra-light and blackened covers for stray light and disturbance light suppression are included. The complete assembly was investigated by extensive thermo-mechanical simulations to verify the stability of the mechanical design under operational, launch loads and test conditions.

## 1 Introduction

Climate change has a considerable impact on the future of our planet. Monitoring the amounts of greenhouse gases in our atmosphere from space is a key element for understanding and controlling this process. Earth observation missions like the “Copernicus Anthropogenic Carbon Dioxide Monitoring Mission” (CO2M) represents a considerable part of ESA’s contribution to monitor greenhouse gases. Missions like CO2M require ever more efficient spectrometers.

One approach to meet the increased optical requirements for the dispersing assemblies of such spectrometers is the use of prisms in combination with gratings (PG- and PG+P-assemblies). The required complexity, size and mass of such arrangements has increased over the past few years. While the PG-Assembly of the Sentinel 5 mission was still a prism and a grating with an air gap in between and a total mass of the two optical components of 0.34 kg, for the CO2M mission, PG+P-Assemblies are currently being designed and built at the IOF, each of which has a weight of up to 3.5 kg for the optics.

To precisely adjust prismatic components and hold them securely for space missions, a kinematic mount including integration technology for a reflective grating made of quartz glass was developed as part of the “Sentinel 4 Grating Unit” project in 2013. This technology has been further developed for the Sentinel 5 PG and is now also used in the PG+P-Assemblies of the CO2M mission.

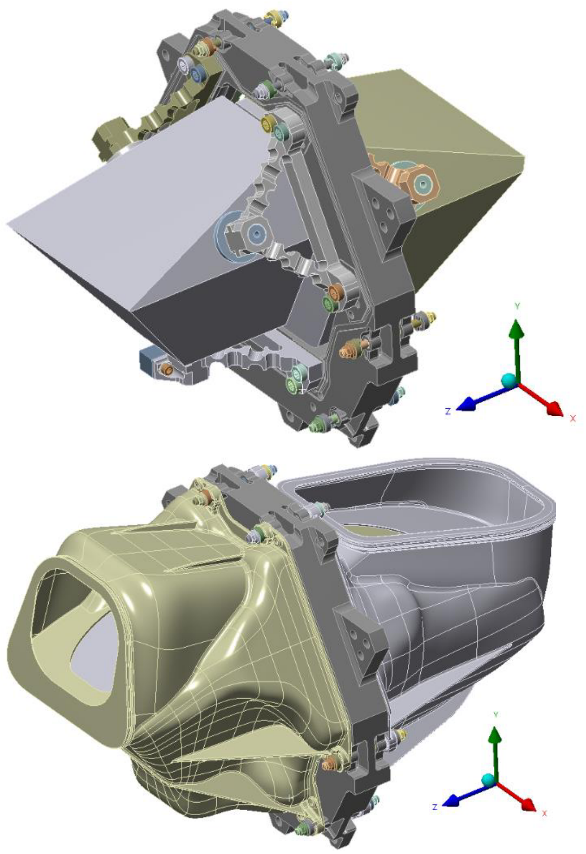

**Fig. 1.** CAD model of the CO2M-SWIR1-PG+P-Assemblies without covers (top) and complete assembly including the covers (bottom)

## 2 Mechanical Design

In the PG+P assemblies for the CO2M mission, the grating is already connected to the first prism before the main integration. The glass components are joint using a direct hydrophilic bonding process [1] without any additional material between the components.

The mechanical design of the mount relies on a kinematic mounting of the optical elements using Titanium bipods which form a hexapod-like structure holding each prism (see fig. 1). The connection between the prisms and the bipods is formed by Invar pins which are glued to both partners of the joint.

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To suppress stray light and disturbance light, the prisms are enclosed in two ultra-light and blackened covers, which are additively manufactured at the IOF using Selective Laser Melting (SLM) [2].

The bipods are screwed to the basic structure and the pins are inserted without fixing them. Then the prisms are placed between the pins and adjusted. The gaps required for this are then closed in a two-step gluing process. Since the prisms are only fixed in the final step, all mechanical stresses previously introduced into the assembly are not passed on to the optics. As a result, a very precise, low-stress and long-term stable mounting of the prisms is possible.

## 3 Results of the thermo-mechanical analysis

FEM analyses are used to verify the stability of the mechanical design of the PG+P assemblies under operational, launch loads and test conditions.

A modal analysis revealed a fundamental frequency of the assembly of 611 Hz, however because of their symmetry properties the lowest three Eigenmodes have negligible impact on the vibration response. The lowest relevant modes are in the range between 882 Hz and 946 Hz, which is compatible with the expected vibration loads.

Similar investigations have been performed with respect to static and temperature loads as well as assembly tolerances. In summary the results of the FEM simulations show that the PG+P assembly will withstand all relevant mechanical and thermal loads.

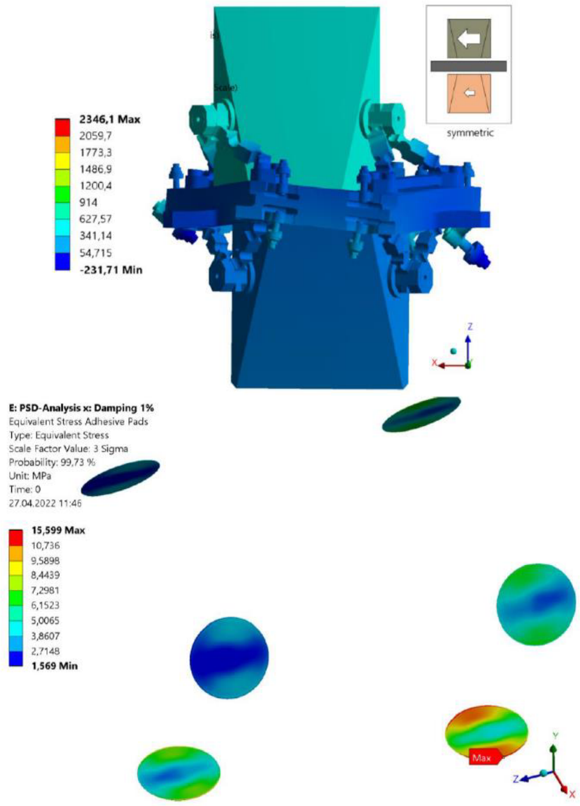


**Fig. 2.** Lowest relevant mode of the CO2M-SWIR1-PG+P-Assembly (top, covers suppressed for display only) and corresponding stress in the adhesive joints under vibrational excitation in x (bottom).

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Views and opinion expressed are however those of the author(s) only and the European Commission and/or ESA cannot be held responsible for any use which may be mode of the information contained therein

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