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ADVANCES FOR UHV SYSTEMS FOR COLD ATOM EXPERIMENTS IN SPACE

Abstract

The Center of Applied Space Technology and Microgravity (ZARM) at the University of Bremen has a major role in the development and design of the scientific payloads for the missions MAIUS-1/2/3 (Matter-Wave Interferometry under Microgravity) and BECCAL (Bose-Einstein Condensate – Cold Atom Laboratory). The MAIUS-1 payload launched successfully on board a VSB-30 sounding rocket in 2017 and created a Bose-Einstein Condensate (BEC) with Rubidium-87 in space. The subsequent missions MAIUS-2 and MAIUS-3 are using the same payload, called MAIUS-B, and they are planned to perform quantum optical experiments including dual-species atom interferometry using BECs of Rubidium-87 and Potassium-41. The BECCAL project pursues the aim of providing a facility for experiments with cold atoms and BECs aboard the International Space Station.

In order to perform quantum optical experiments as planned in the aforementioned projects, a pressure of less than 5×10^{-8} Pa is required and must be maintained in the experiment chamber of the scientific payload. The payload has to withstand accelerations and vibration loads that occur during launch, re-entry, and throughout the flight. To avoid a decreased performance of the experiment, the UHV system needs to be able to maintain the required pressure level. For such an UHV system, the final pressure is an equilibrium of the pumping system on the one side, and the outgassing and leakage rate on the other side. Thermal and mechanical loads, as they appear during the MAIUS or BECCAL missions, have a significant impact on these values. This paper will introduce the different testbeds for the outgassing and leakage rate tests under mechanical and thermal loads. The findings of these tests are also incorporated into the designs of the MAIUS and BECCAL vacuum system.

Furthermore, novel simulation techniques used to design vacuum systems for space payloads are discussed and an overview on the design, assembly and integration processes of the current status of the BECCAL vacuum system prototype is presented.