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Test results of sorption-based helium-3 pump for a closed-cycle dilution refrigerator

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A sorption-based helium-3 pump is developed to be incorporated in a closed-cycle dilution refrigerator (CCDR) that is realized by the Néel institute in Grenoble. This CCDR is to be used for future long-lifetime space missions requiring a cooling power of the order of 1 microWatt at typically 50 mK for at least 5 years. A crucial component in this zero-gravity dilution refrigerator is a pump to circulate helium-3 between 5 and 200 mbar. For this purpose, we designed a sorption-based pump that consists of a single sorption-compressor cell of which the sorber container measures 1 cm in diameter and 10 cm in length. It uses passive inlet and outlet valves and is thermally linked to a 15-K platform. Gas buffers are applied for stabilizing the low pressure and for storing the gas at 300 K thus reducing the filling pressure to below 20 bar. The pump is manufactured and tested. A compressor-cell input of 60 mW is required to establish a flow of 20 micromol/s between 5 and 200 mbar. The pressure fluctuation in that case at the low-pressure side is about 1,5 mbar. If needed, this fluctuation can be reduced to about 0,5 mbar by controlling the temperature of the low-pressure buffer (requiring an additional power input of 60 mW). Compared to mechanical pumps the main advantages are lower mass and less complex interfacing. Both advantages result from the fact that the pump is fully integrated with the cold part of the CCDR, whereas the alternative mechanical pumps need to be operated at the 300 K level. The construction of the sorption-based pump and test set-up will be presented as well as the test results.

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