Space Cryocooler Developments

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Abstract – The need for cryogenic cooling in space has become of increasing importance with time. In many space sciences projects cryogenic detectors are essential for the accomplishment of the scientific objectives. Several other components such as the optics can benefit from a cryogenic cooling which reduces the radiative loading on the detectors. The current trend in space cryogenic is to develop cryogen free satellite, i.e. suppress the liquid reservoir for mechanical coolers. Although liquid cryostat is a straightforward technique, it leads to heavy reservoirs and structures and by essence limits the mission duration. For low temperature, several systems must be chained together to cover the temperature range, which now extends to 50 mK for some future space missions. Obviously the overall performance of the cryogenic chain depends on the performance of each links, on their ability to operate together and finally on the compatibility with the detectors. The use of mechanical coolers can require dedicated devices to distribute the cooling effect far from the cooler cold head and/or to deal with the temperature stability and limited instant cooling power. For decades development programs have been carried out to produce space cryocoolers able to provide net heat lifts at various temperature. At the European level, the laboratories and industries involved in space cryogenics are now in a position to propose full cryogenic chains from ambient temperature down to 20 mK. In this paper we will give an overview through selected examples, and a particular focus on European developments will be made.

Keywords – Cryogenic cooling, cryogenic detectors, cryogen-free cooling, space cryogenics, cryogenic heat switches, radiative cooling, mechanical coolers, hybrid coolers, space dilution coolers, helium sorption coolers, subkelvin coolers, multistage pulse tube, ADR