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Development of a closed-cycle miniature dilution refrigerator for a fast-cooldown 100 mK detector wafer test cryostat

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The forthcoming generation of Cosmic Microwave Background polarization observatories are developing large format detector arrays which will operate at 100 mK. Given the volume of detector wafers that will be required, fast-cooldown 100 mK test cryostats are increasingly needed. A miniature dilution refrigerator (MDR) has been developed for this purpose and is reported. The MDR is pre-cooled by a double stage $^3\text{He}/^4\text{He}$ Chase Research Cryogenics "Berkeley-style" sorption refrigerator. The test cryostat based around this MDR will enable fast cooldown to 100 mK to support rapid feedback testing of detector wafers fabricated for the Simons Observatory. The MDR has been designed so as to be retrofitted to existing CRC10 sorption coolers, reducing the base temperature from 250 mK for the new generation of detectors. This configuration will meet the cryogenic requirements for single-wafer testing, providing $\sim 5\text{-}10 \mu\text{W}$ of cooling power for several hours. The system operates in a closed cycle, therefore avoiding external gas connections and cold o-rings. No moving parts are required, with the system operated entirely by heaters. It is possible to fully automate the cycling of each stage in order to provide "push-button" cooldown to 100 mK. Furthermore, the architecture of the system that has been developed is such that it could easily be implemented for other low-temperature detector applications requiring similar cooling powers.

Less than 5 years of experience since completion of Ph.D

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Student (Ph.D., M.Sc. or B.Sc.)

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