

Cryogen-free Dilution Refrigerators

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We review briefly our first cryogen-free dilution refrigerator (DR) which was pre-cooled by a Gifford-McMahon cryo-cooler. We then show how today's dry DRs with pulse tube pre-cooling have developed; a few examples of commercial DRs are explained and noteworthy features pointed out. Thereby we describe the general advantages of cryogen-free DRs, but also show where improvements are still desirable.

At present, our dry DR has a base temperature of 10 mK and a cooling capacity of 700 μ W at a mixing chamber temperature of 100 mK. In our cryostat, in the most recent work, an additional refrigeration loop was added to the dilution circuit. This ^4He circuit has a lowest temperature of about 1 K and a refrigeration capacity of up to 100 mW at temperatures slightly above 1 K; the dilution circuit and the ^4He circuit can be run separately or together. The purpose of this additional loop is to increase the cooling capacity for experiments where the cooling power of the still of the DR is not sufficient to cool cold amplifiers and cables, e.g. in studies on superconducting quantum circuits or astrophysical applications.

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