

A novel system for providing a 4.5 Tesla rotating vector with ultra low temperature capability to study quantum effects in semiconductor nanostructures

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We report the test results obtained on a Leiden Cryogenics cryogen-free Dilution Refrigerator with a 1.5 Watt Pulse tube cryocooler integrated with a Cryogenic Limited Cryogen-free 9T-5T-1T vector magnet also cooled by a separate 1.5 Watt CryoMech Pulse tube cryocooler.

The system was developed for use in research in spintronics and in particular the control and manipulation of the spins of spatially confined charge carriers in semiconductor heterostructures such as AlGaAs/GaAs. The entire system cooled from room temperature to operating temperature in 60 hours. The Dilution Refrigerator alone cools to operating temperature in 24 hours but the large 3 axis magnet extended the cooldown time. This cooldown time could have been reduced by means of a liquid nitrogen precool circuit which is installed in the system.

The base temperature of the system achieved was 10mK with a static field vector of 4.5Tesla in the XZ plane. Continuous rotation of a 4.5 Tesla field vector in the plane showed a small elevation in temperature up to 18mK due to eddy current heating in the Dilution Refrigerator mixing chamber. The system recovered to 10mK in a few minutes when field rotation ceased.