

Angle-dependent magneto-transport measurements at mK temperatures with an ANR30/LT

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Based on an attocube systems rotator ANR30/LT (see Figure 1) a rotation stage for angle-dependent transport measurements in magnetic fields up to 33 T and temperatures down to 40 mK was built at the user facility of the High Field Magnet Laboratory in Nijmegen.

The mixing chamber of the commercially available dilution refrigerator from Leiden Cryogenics offers only a limited space of 17 mm in diameter. Hence, the ultra compact attocube rotator ANR30/LT is the positioner of choice for this task. Figure 2 shows the rotator which is fixed on a plastic (Hysol) dilution refrigerator insert.

The angular movement of the ANR30/LT is transmitted via a thin copper wire (100 μm diameter) to a rotating sample stage with a home-made 20-pin spring-contact socket for samples mounted into standard LCC-20 packages. The contacts are connected to a fixed 40-pin connector of the dilution refrigerator using copper wires with a diameter of 30 μm to minimize the mechanical load on the rotator. The voltage pulses which are needed for driving the rotator are supplied via the same 40-pin connector using two parallel wires for each contact. Due to the small capacitance of the ANR30/LT of only 14 nF at low temperatures, the relatively high resistance of the cabling of approx. 36 Ohm in total does not raise a problem for the rotator. The additional LEDs which are also marked in Figure 2 enable excitation of additional carriers in semiconductor samples.

A GaAs-heterostructure Hall-bar was mounted onto the described insert and the angle dependent Quantum Hall Effect between 0 and 52 degrees was measured at a temperature of 40 mK (see Figure 3). At $q = 0^\circ$ the sample is oriented perpendicular to the magnetic field. A driving voltage of 70 Volts at $f = 1000$ Hz was used to rotate the sample. During a typical rotation by a few degrees, lasting several seconds, the dilution refrigerator warmed up only a few tens of mK and its temperature never exceeded 100 mK (independent of rotation time). The step size at these low temperatures and the conditions above was measured as 0.6 \pm 0.05 millidegrees. The angle covers a range from +110 degrees to -50 degrees, only limited by the contact wires' mechanical load.



Figure 1: Ultra compact attocube rotator ANR30/LT with 10 mm diameter and 9 mm height.

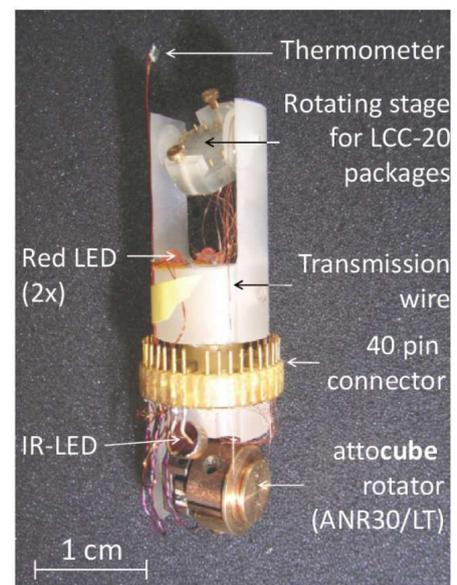


Figure 2: Setup for angle dependent transport measurements with an attocube rotator ANR30/LT which is inserted in a dilution refrigerator.

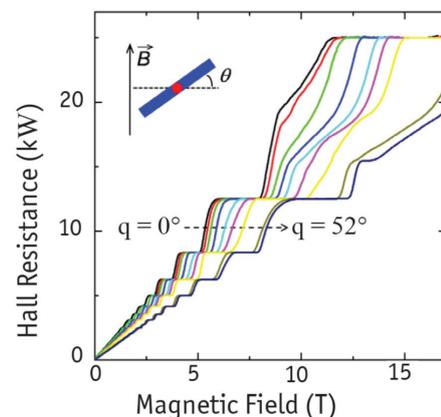


Figure 3: Angle dependent measurements of the Quantum Hall Effect in an AlGaAs two-dimensional electron gas.