Miniature Continuous Flow Helium Cryostat

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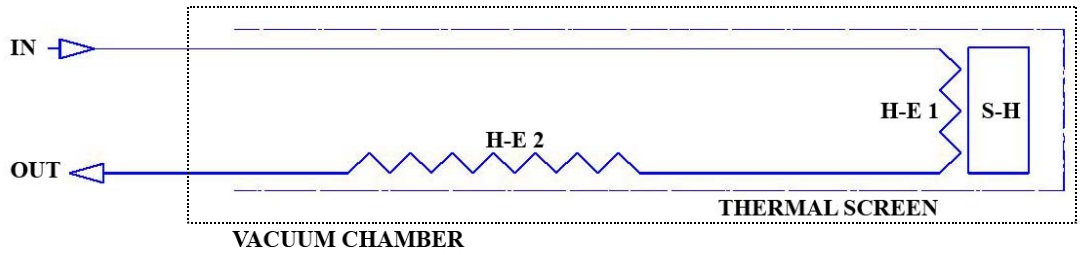
Abstract

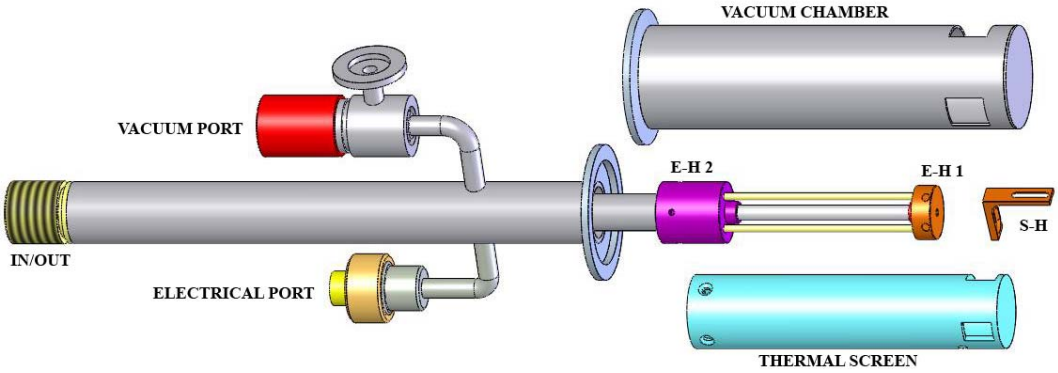
A multipurpose small continuous flow Helium cryostat was designed and constructed for application of a wide range of X-ray measurement techniques. Reaching temperatures from 2K to 325K, this vibration-free instrument can easily be adapted to the beam-line geometry and works in any orientation. Its mechanical modularity, high cooling rate and excellent temperature stability allows for a wide spectrum of experiments such as GID, SAXS, XPCS or XRMF.

1. Design

Following the innovation and development strategy at the ESRF, this instrument is the natural evolution of the XRMS cryostat [1] presented at MEDSI 2004.
The working principle is the same as most continuous flow cryostats: the cryogen is continuously delivered to the cryostat by means of a flexible siphon, thermalized in a first heat exchanger (H-E 1) where it cools the sample holder and returned through a second heat exchanger (H-E 2) where the remaindre of the enthalpy is used to cool down the thermal screen.



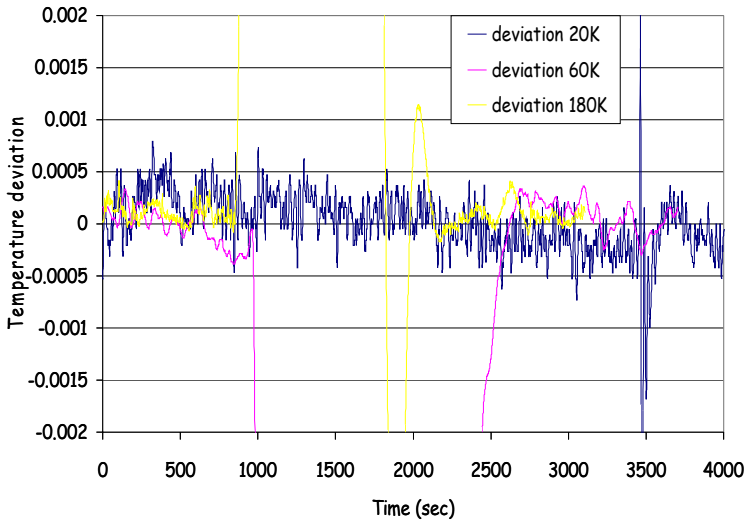
For temperature control a heater and a thermometer are mounted in the first heat exchanger. A second thermometer in the sample holder allows a measurement of the temperature in those cases in which the temperature gradient is not negligible.



Both heat exchangers are gold plated to improve the thermal transfer. Special care was paid to have a good fit between H-E 2 and the thermal screen.
Sample holder, thermal screen and vacuum chamber are made to the needs of the experiment.

2. Performances

The lowest temperature was reached using a Leybold Sogevac [24m^3/h] pump and a He transfer tube Oxford LLT600/13 was 1.95K. The lowest working temperature is about 2K with a power of 30 mW and the useful temperature range can be extended to above room temperature. The cryogen consumption is very low: 13.4 l/day at 2K, 7.3 l/day at 10K and 2.9 l/day at 100K. Using a Lake Shore 340 temperature controller, the stability ($\Delta T/T$) measured over the whole range was better than 10^{-3}. The excursions in fig. 3 are due to temperature steps of bigger than 2% during the run.



Temperature stability: deviation from the set temperature for 20, 60 and 180 Kelvin smaller than 10^{-3} over the whole temperature range

The stand by of the device is only the time necessary to pump, to a pressure lower than 10^{-5} bar, a volume of ~0.2 l. The cool down time of the siphon is ~6 min and only a few tens of seconds are required to go from room temperature to 4K.

Measurements made by the way of an infrared luminescence quantum dot microscopy experiment, using a special adaptation of this device, have shown that the vibration level is lower than 1μm.

[1] Flow cryostats for use in synchrotron facility - Ricardo Steinmann – Medsi 2004