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Andrei Golov: Dilution Refrigeration in Manchester

I will show three short videos of Henry Hall speaking about the development of dilution refrigeration in the 60s (interviewed and filmed by Minoru Kubota in Manchester on 10.03.2003).

In https://youtu.be/wBfp9ZDP4Os, Henry speaks about the role of Heinz London, the early experimental attempts by London, Clarke and Mendoza at Harwell, and the acknowledgement of his own ideas in the footnote of their paper (next slide).

PHYSICAL REVIEW VOLUME 128, NUMBER 5 DECEMBER 1, 1962

Osmotic Pressure of He^3 in Liquid He^4, with Proposals for a Refrigerator to Work below 1°K

H. LONDON AND G. R. CLARKE
Atomic Energy Research Establishment, Harwell, England

AND

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(Received September 21, 1961; revised manuscript received May 14, 1962)

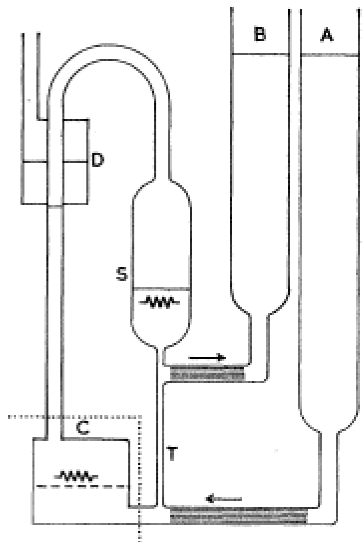


FIG. 9. Schematic diagram of dilution refrigerator. Dotted line separates cryostat *C* from recirculating mechanism. Dashed line in cryostat represents phase boundary, with concentrated He^3 solution on top. T is narrow capillary to flush dilute He^3 into still S. D is condenser. He^4 circulates from bath A through superleak, through T and out again through another superleak into bath B at higher temperature.

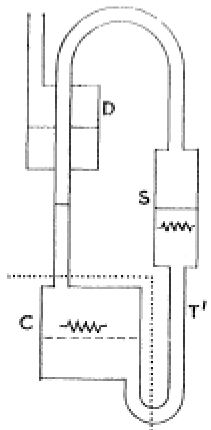
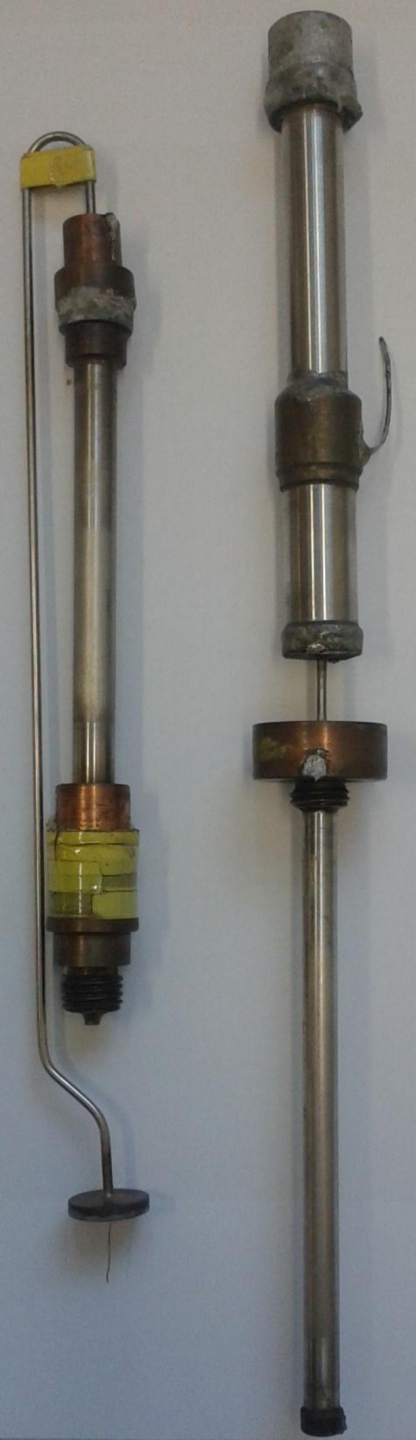


FIG. 10. Schematic diagram of dilution refrigerator. Cryostat C is like that in Fig. 9, but flow of dilute He^3 into still S is through wide tube T′ and is nonturbulent. Motive force pulling He^3 round is pumping action exerted by condenser D.

A third quite different arrangement[35] (not illustrated) makes use of the fact that the difference of enthalpy of dilute He^3 between 0.1 and 0.6°K (about 1.5 cal/mole) is considerably greater than the enthalpy of pure (or even 95%) He^3 at 1°K. It is therefore possible to dispense with the He^3 condensing bath D. This can be done by bringing the vapor from the still up to room temperature, recompressing it by a diffusion pump, and condensing it in a He^4 bath at 1°K. A heat exchanger has to be employed between this liquid and the dilute solution between the cryostat and the still. It may be noted that in order to produce the same throughput of He^3 round the refrigerating circuit, the size of pump necessary to circulate the concentrated distillate in this arrangement is practically the same as that needed on the pure He^3 in the condenser *D* of Fig. 9 or 10. At the same time the design problem posed by the need for good heat transfer through the condensed *D* is replaced by that of the exchanger leading to the cryostat—a problem which is simplified by the smallness of the heat load there. This arrangement has the further advantage that the concentrated He^3 entering the cryostat can be precooled to an even lower temperature than that attainable with an ordinary He^3 bath, thus making it possible that an even lower temperature might be reached than with the other arrangements illustrated.

[35] It was suggested by Professor H. E. Hall.



A HELIUM-3 DILUTION REFRIGERATOR

H. E. HALL, P. J. FORD,† and K. THOMPSON
The Physical Laboratories, University of Manchester, U.K.

Received 16 February 1966

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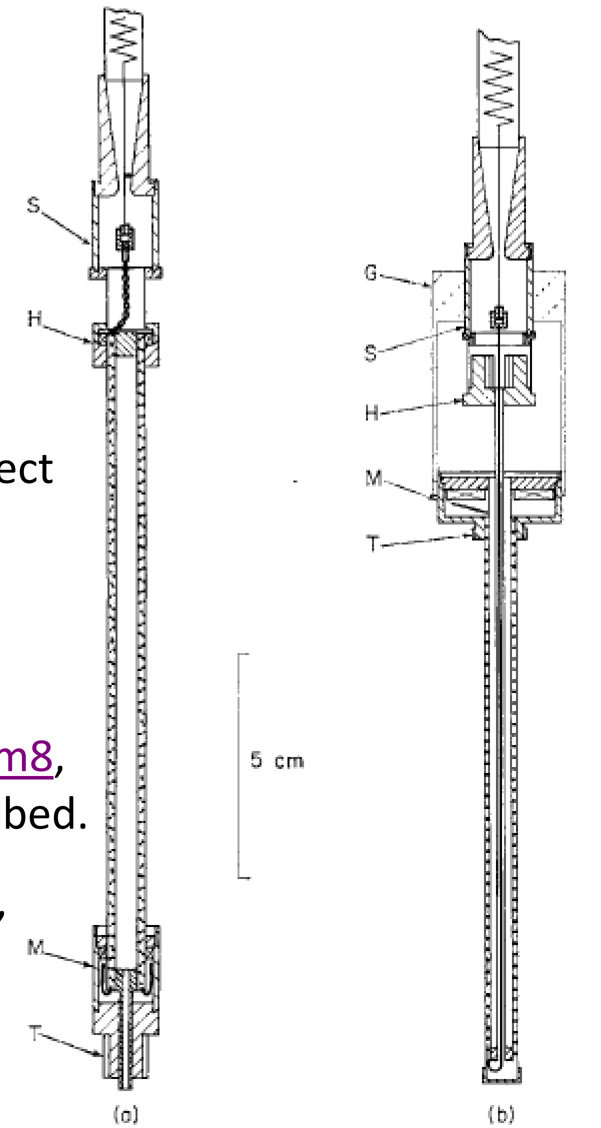
In https://youtu.be/p8z4sFmw7Bo, Henry speaks about his involvement into the project and the first refrigerator marred by the convective instability.

In the last clip, https://youtu.be/tY0Iq-tO3m8, the second, successful refrigerator is described.

He refers to them as the ``left'' and ``right'' as they are shown in the paper.



S: Still. H: Still heater. G: Graphite precooling link and mechanical support. M: Mixing chamber. T: Screw thread for attachment of load

Figure 2. (a) The first refrigerator. (b) The final refrigerator

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Dilution refrigerators in Manchester in 2015

Currently, two groups in the School of Physics and Astronomy use and develop dilution refrigerators for special applications (see next two slides):

- Low Temperature Group: three dilution refrigerators in use (two of which rotating)

- Jodrell Bank Centre for Astrophysics: develop compact & tilting dilution refrigerators

A compact rotating dilution refrigerator

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[1]*School of Physics and Astronomy, The University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom*
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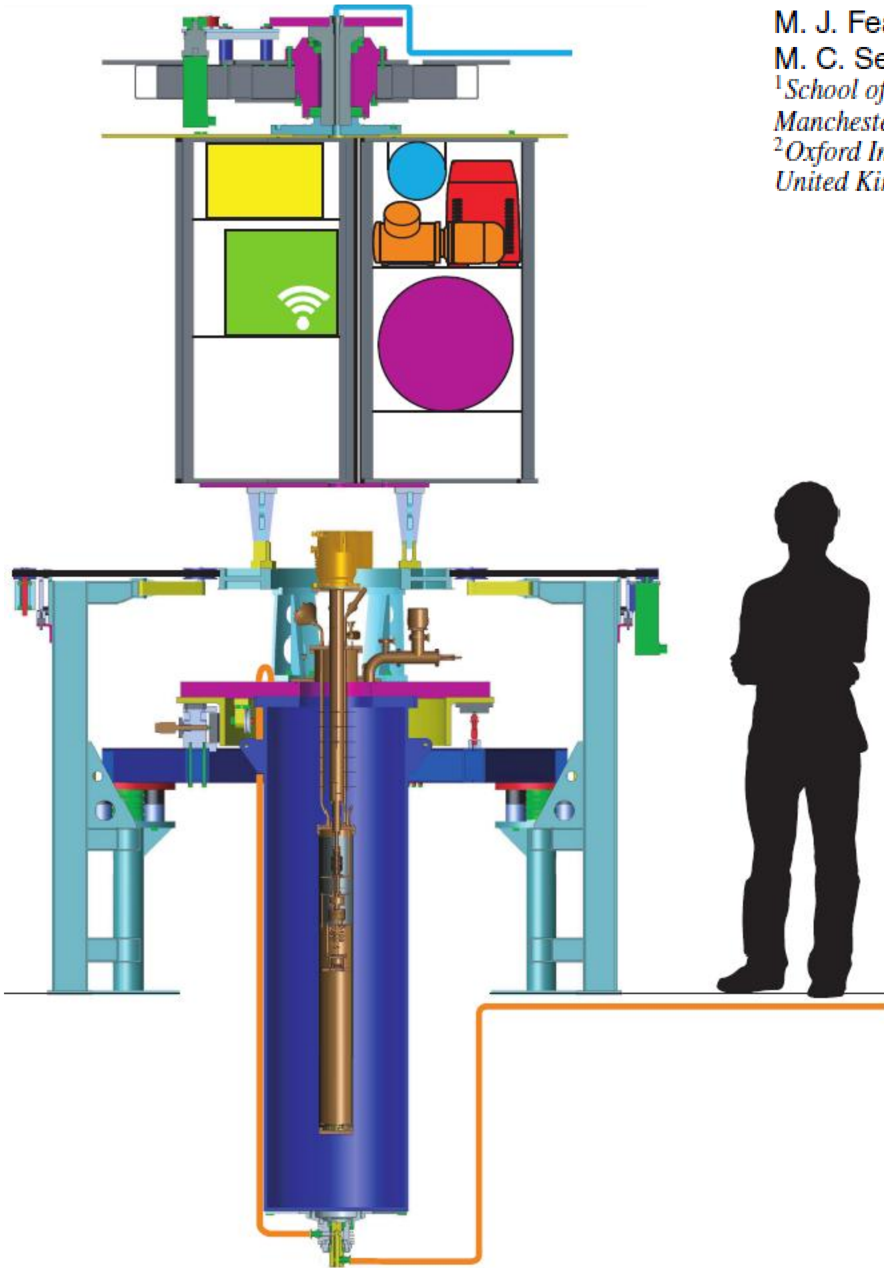
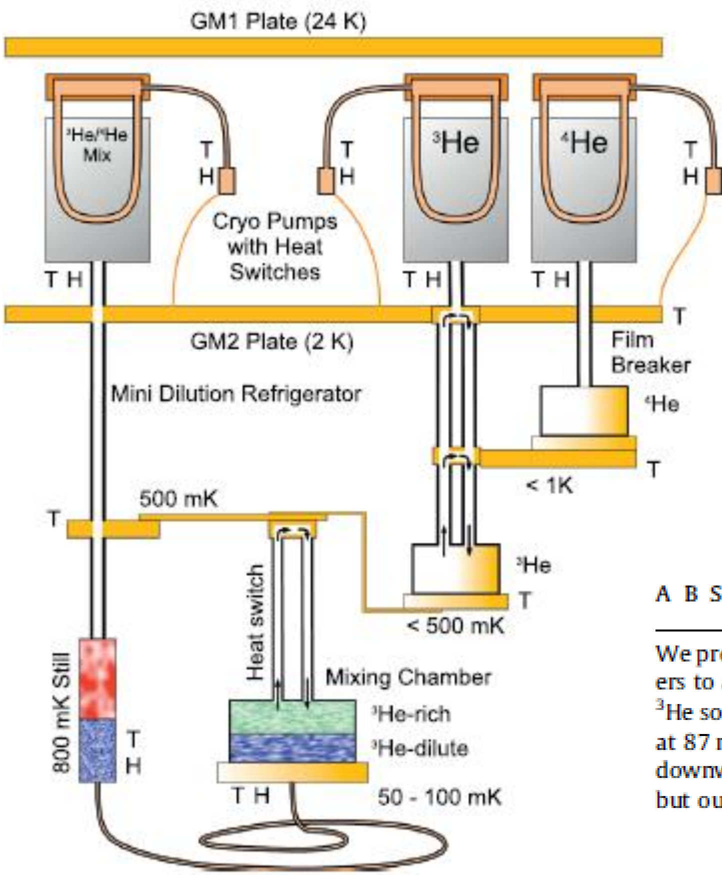


Cryogenics 55–56 (2013) 63–67

A tiltable single-shot miniature dilution refrigerator for astrophysical applications

Simon J. Melhuish *, Lorenzo Martinis, Lucio Piccirillo

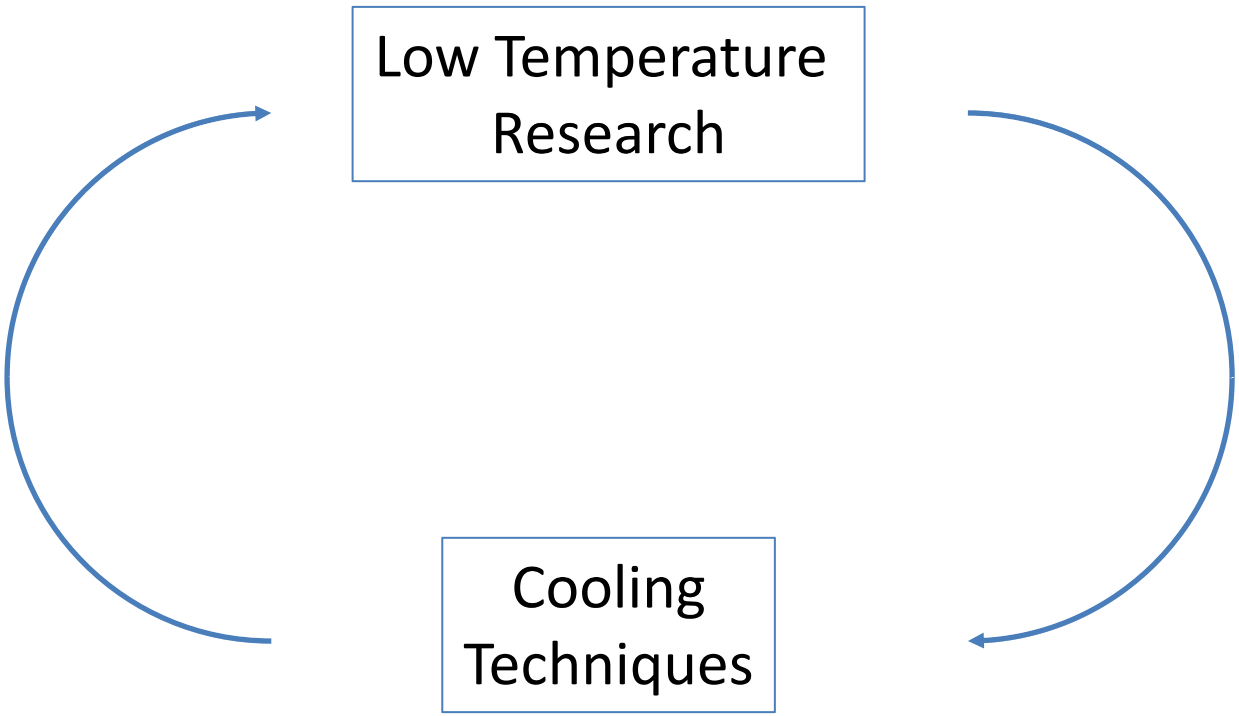
Jodrell Bank Centre for Astrophysics, Alan Turing Building, School of Physics and Astronomy, The University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom



A B S T R A C T

We present a ^{3}He/^{4}He dilution refrigerator designed for cooling astronomical mm-wave telescope receivers to around 100 mK. Used in combination with a Gifford–McMahon closed-cycle refrigerator, ^{4}He and ^{3}He sorption-pumped refrigerators, our cryogen-free system is capable of achieving 2 μW cooling power at 87 mK. A receiver attached directly to the telescope optics is required to rotate with respect to the downward direction. This scenario, of variable tilt, has proved difficult for typical dilution refrigerators, but our design has a geometry chosen to allow tilt to 45° and beyond.

50 years of Dilution Refrigeration



Thank you! Conference closed, life goes on!