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C2Or2C-02: A new type of mixing chamber for a zero gravity dilution refrigerator

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A proven design for a zero gravity dilution refrigerator consists of three capillaries soldered in parallel to form a heat exchanger. The mixing chamber is an T-junction at the cold end of the exchanger. Almost pure liquid ^{3}He and pure liquid ^{4}He flow through the two outside capillaries to the cold end where they mix in the T-junction causing dilution cooling. The cold liquid ^{3}He-^{4}He mixture leaves the T-junction through the middle capillary.

This refrigerator works only when a fraction of ^{3}He remains in droplets of concentrated phase forming plugs in the outlet capillary that separate chunks of dilute liquid ^{3}He-^{4}He. This arrangement of coexisting concentrated ^{3}He and dilute ^{3}He-^{4}He liquid has a subtle thermodynamic consequences: the enthalpy of this system can be less than that of the same amount of dilute liquid without the concentrated phase. Therefore, the dilution refrigerator on the Planck satellite had almost a factor 2 less cooling power than predicted on basis of simple, but wrong arguments.

We have designed and tested a new type of heat exchanger for the zero gravity dilution refrigerator with a silver sinter that changes thermodynamic conditions leading to an improvement of cooling power of 60 %. In addition, the silver sinter improves also the thermal coupling between the coolant and the outside world. We will explain the physics and the new design as well as present the experimental results.

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