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EXCHANGE OF POLARIZED TARGETS IN A HIGH MAGNETIC FIELD AND AT mK TEMPERATURES

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ABSTRACT

A lifting mechanism has been installed in our cryostat, which allows to change targets at high magnetic field (9 T) and low temperature (10 mK). Its construction is described, and the temperature measured during regular target exchange is presented.

1. Introduction

In our facility KRYPTA |1| polarized targets for neutron scattering experiments can be produced with the brute-force method. The cryostat contains a ^{3}He - ^{4}He dilution refrigerator with a base-temperature of 5 mK and a split-pair superconducting 9 T magnet with a gap of 26 mm and a bore of 95 mm. Presently it is employed to study the spin correlation parameter A_{yy} in the scattering of polarized fast neutrons by polarized protons.

As polarized proton target a sample of pressed TiH_2 powder is employed |1,2|. The properties of the neutron beam do not allow to separate the neutrons scattered by protons from those scattered by titanium by means of time-of-flight techniques or other methods. Therefore, the scattering by protons has to be obtained by subtracting the scattering by a pure Ti-target from the scattering by TiH_2.

Exchanging the targets by warming up the cryostat, opening it and cooling down again costs about one week due to the size of the magnet (weight ~ 270 kg) and to the rather long polarization build-up time of the TiH_2 |1|. It is questionable whether detectors and electronics can be kept stable enough for a valid subtraction of the scattering events. Therefore, we looked for a method to exchange the samples while maintaining the dilution refrigerator at low temperature and the magnet at high field.

2. Realization

The insert of our dilution refrigerator (constructed by Oxford Instruments, Oxford, UK) is completely situated inside the helium vessel of the cryostat. The only connection to the cryostat is at the top plate of the insert. The majority of the vertical dilution refrigerators is constructed in this way. This provides the possibility, after disconnecting the top plate, to move the insert with the sample in the vertical direction relatively to the rest of the cryostat and the magnet. In this way two samples, which have been mounted above each other, can be positioned in the beam alternately. Figure 1 shows schematically how we mounted the TiH_2 and Ti samples in our cryostat. Their centres are a distance of 38 mm apart. The samples have a thickness of 35 mm and a diameter of 27 mm, including 1 mm wall thickness of the surrounding copper cylinder.

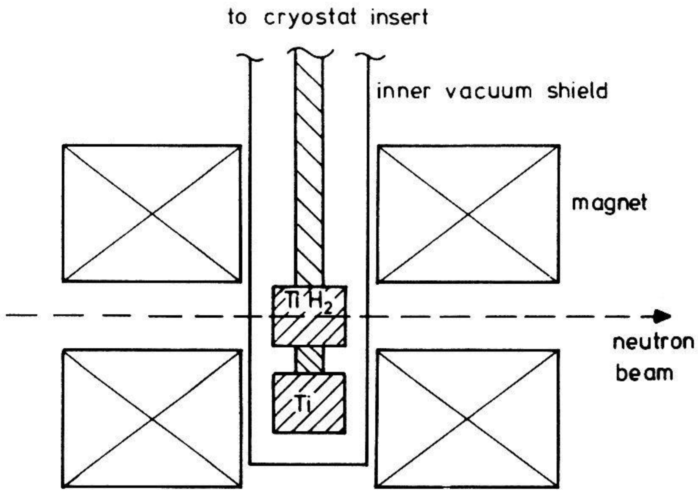

Fig. 1 Relative position of the TiH_2 and Ti samples in the cryostat.

The lifting mechanism has been constructed as a wormgear driven elevator. Its construction is shown in Fig.2. In the original situation the top plate (1) of the insert rests on the upper flange (4) of the helium vessel. These two have been separated for the installation of the lifting mechanism. Its main component is a worm gear (7 and 8) contained in a ring-shaped box (5).

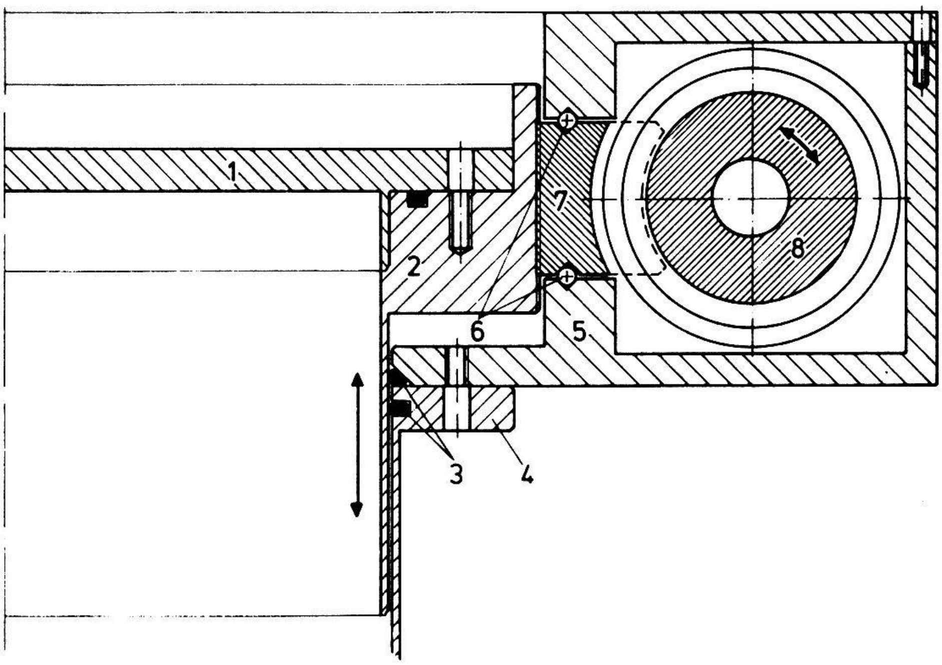

Fig. 2 Lay-out of the driving mechanism for the vertical movement of the cryostat insert. 1. insert top plate; 2. support ring for insert top plate; 3. sliding O-ring seals; 4. top flange of helium vessel; 5. ring-shaped box containing worm wheel; 6. ball bearings; 7. worm wheel; 8. worm gear.

The worm wheel (7) has a screwthread at its inside, fitting into the screwthread at the outside of the ring (2), which carries the top plate (1). Wheel (7) is supported by ball bearings above and below. Its vertical position is fixed. Its rotation therefore enforces a raising or lowering of ring (2) and thus of the cryostat insert with the targets. The worm gear (8) is driven by an electromotor through a gear unit to reduce the rotation speed. In this way a sample exchange, i.e. a vertical displacement of 38 mm, is realized in 67 min.

The lower part of the ring (2) is a piece of thinwalled tubing, which closely fits into the neck of the helium dewar. The helium space is closed by two sliding O-ring seals (3) positioned shortly above each other.

3. Performance

The target lifting mechanism has been employed recently in a neutron scattering experiment, which lasted about one week. Figure 3 shows the measured temperature as a function of time. It was obtained by measuring the γ-anisotropy of a ^{60}CoCo sample connected to the outside of the TiH_2 target. Also indicated in Fig.3 are the times when a target exchange was carried out and the specification of the target in the beam. The target was changed about once each day. It can be seen, that the target replacement had little or no influence on the temperature.

In the second part of the experiment the temperature seems to be systematically higher during the intervals with the TiH_2 target in the beam compared to the intervals with the Ti target in the beam. This can possibly be ascribed to a difference in heating by the neutron beam. Both targets contain the same amount of Ti-nuclei. The extra proton recoils in the TiH_2 target give rise to a heat load of the order of 0.1 μW at the average intensity and energy distribution of our neutron beam.

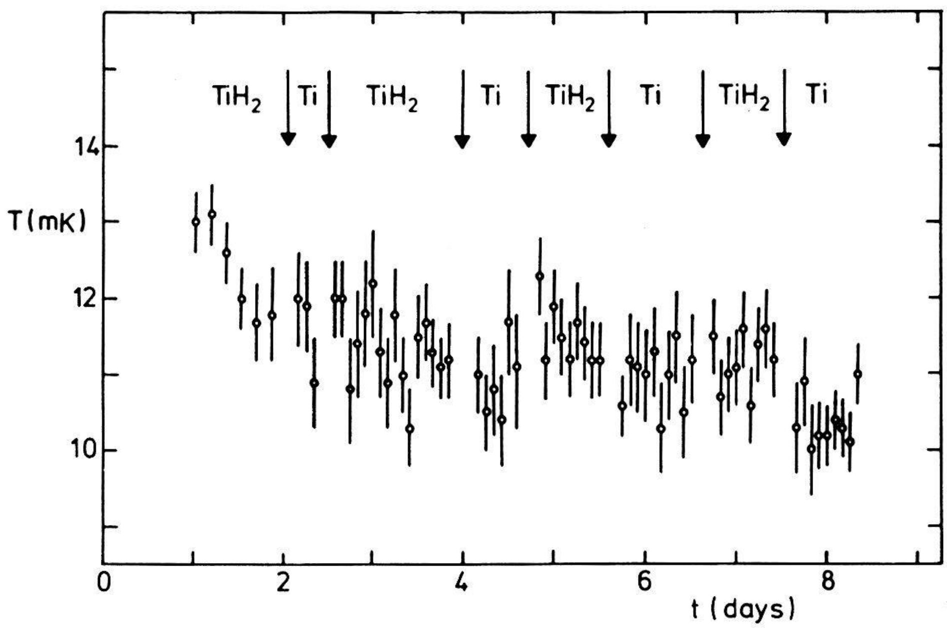

Fig. 3 Temperature measured at the outside of the TiH_2 target plotted against time. The arrows indicate when a target exchange has taken place.

We conclude, that the target lifting mechanism functions very well and that its impact on the polarization of the protons in the TiH_2 sample is negligible. This facility is of great importance for the reduction of systematic errors in our measurement of the A_{yy} spin correlation parameter in n-p scattering.

4. References

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