# Hydrogen and Nitrogen Droplet Production with the ANKE Pellet Target*

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The Preparation of the pellet-target facility for operation at an internal target position of COSY has made significant progress in 2003. The most important results were obtained during test runs in the second half of the year: micro droplets of frozen hydrogen have been observed behind the exit sluice from the triple point chamber (TPC) and a continuous flow of liquid nitrogen droplets could be generated which has been injected into the first vacuum chamber.
The test results presented in this article have been obtained with the fully assembled pellet target. The setup now comprises four turbo pumps to improve the vacuum conditions in the flight sections (*i.e.* vacuum chambers behind the TPC). Without gas flow from the sluice a pressure of $\sim 6 \cdot 10^{-8}$ mbar has been obtained. During permanent operation with gas flow from the TPC (pressure 80–100 mbar) and freezing hydrogen or nitrogen droplets the vacuum in the first flight section was $\sim 5{\cdot}10^{-4}$ mbar and $\sim 5{\cdot}10^{-5}$ mbar in the second. These values are in an agreement with numerical estimations. During three weeks of test runs a new system for automatic refilling of liquid nitrogen provided stable target operation. Refilling of the 300 liter liquid nitrogen tank is required only once per week.

**Regimes of liquid droplet production**

The measurements on liquid hydrogen jet and droplet flow behavior in dependence of the TPC temperature and pressure have been performed with a modified target cryostat. The data have been obtained with open sluice to the first vacuum chamber and confirmed earlier results with a closed system. A stable hydrogen jet and droplet flow (see Fig. 1) is generated at thermodynamic conditions close to triple point conditions, $T = 15$ K and $p = 100$ mbar, and at a relatively low jet velocity $\sim 2$ m/s and large droplet size $\sim 60-80\,\mu$m. Temperature deviations of 20% lead to phase transitions: if the temperature increases by 3 K a mixture of two phases (liquid and vapor) is observed whereas a temperature drop by 3 K leads to jet freezing and blocking of the nozzle.

**Frozen $H_2$ and $N_2$ droplet production**

During the tests frozen droplets and their fragments — solid hydrogen corpuscles — were observed during periods of several days, see Fig. 2. The reason for having a rather unstable flow of hydrogen corpuscles at the sluice output was a poor adjustment of the jet generating nozzle (60 $\mu$m diameter, 3 mm length) and the sluice (600 $\mu$m diameter, 60 mm length) axes. This problem will be solved in 2004 with a modified adjustment system. The liquid droplet flow has been generated from a stable liquid hydrogen jet with 60$\mu$m diameter and $\sim$ 3m/s velocity. The generation frequency has been varied between 3–4 kHz.
During a second test new metal nozzles with channels of 38$\mu$m diameter have been used and, for the first time, frozen nitrogen droplets have been observed. Figure 3

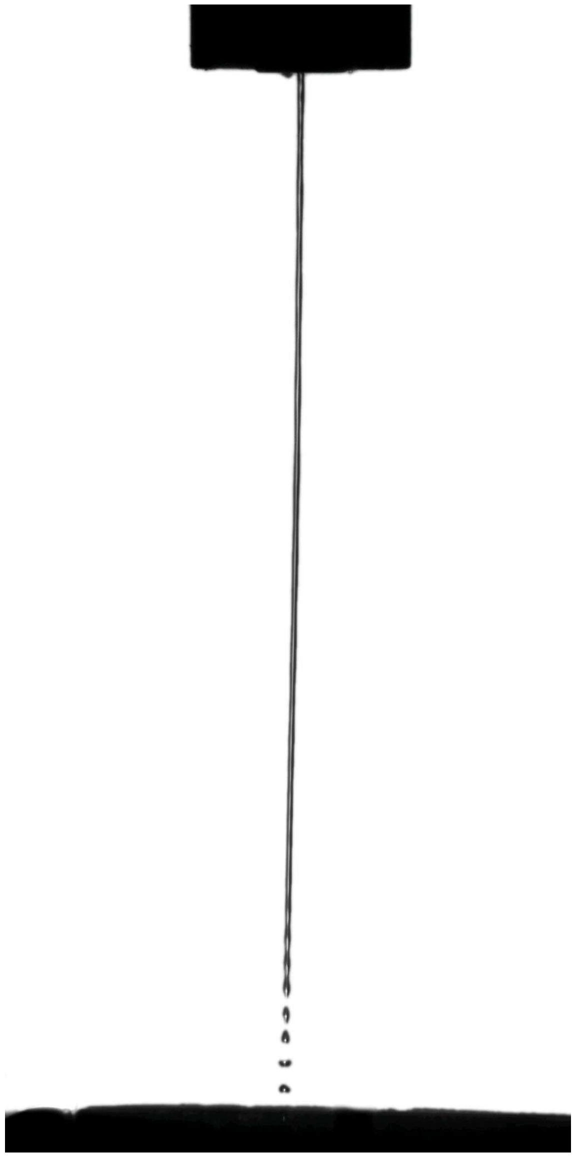

Fig. 1: Hydrogen droplet flow generation from a jet of 60 $\mu$m diameter.

shows the liquid nitrogen jet in the TPC at nitrogen triple point conditions and a droplet generator frequency of 3 kHz. The temperature in the gas condenser was stabilized and controlled with our ordinary helium cooling system. The measured temperature and pressure parameters for nitrogen droplet and pellet production are in agreement with theoretical expectations.
During all tests of hydrogen (8 days) and nitrogen (4 days) droplet production no nozzle blockages caused by frozen liquids or impurities have been observed.

**Pellet diagnostics**

In order to observe fast (20–50 m/s) frozen hydrogen droplets as well as liquid jets and droplets with diameters of less than 100 $\mu$m a diagnostic system based on two fast CCD cameras has been developed. Two fast flash lamps (flash length less than 1 $\mu$s) with special

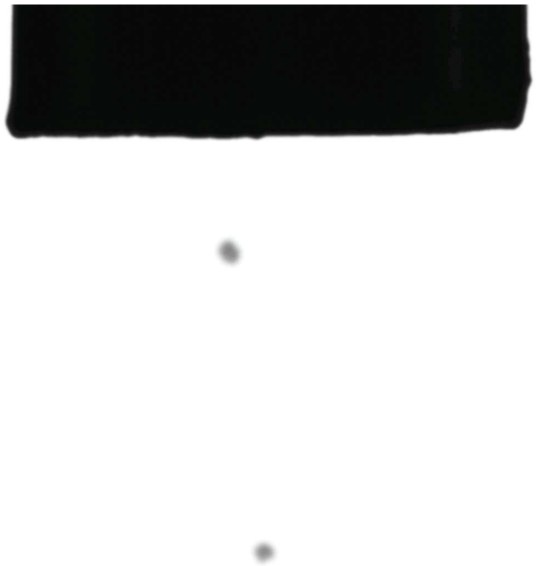

Fig. 2: Frozen hydrogen droplets at the sluice outlet.

power supplies have been developed and assembled. The fully installed diagnostic system includes:
a) Two video cameras type PixelFly Scientific
b) Special optic lenses
c) Flash lights
d) PC, interface modules, software and connecting lines.

**Conclusions**:
The ANKE pellet target has been used to produce continuous flows of liquid hydrogen and nitrogen droplets. It is expected that regular pellet (*i.e.* frozen droplet) production will be achieved in 2004 with installation of a new sluice adjustment system. Thus, the target prototype has demonstrated its capability to generate pellets from different liquefiable gases.
A new technology for the production of nozzles for cryogenic micro jet has been developed. Metal nozzles with 38 $\mu$m channel diameter have been successfully tested under realistic cryogenic conditions.

**References:**

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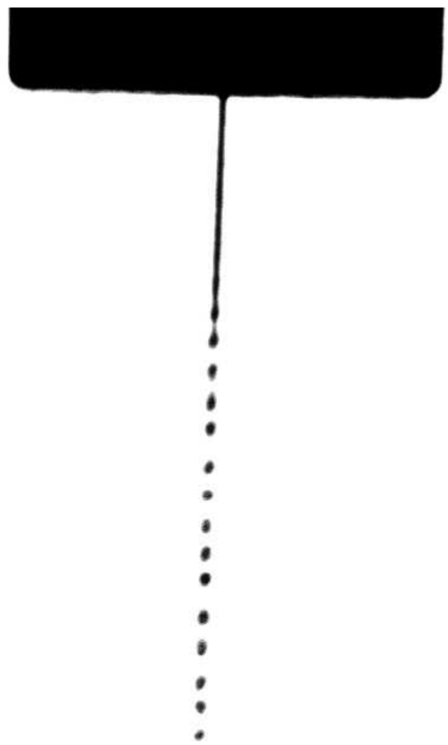

Fig. 3: Nitrogen droplet generation from jet of 38 $\mu$m diameter.