Study of liquid hydrogen jet properties close to triple-point conditions*

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The goal of our measurements was a study of boundary conditions for stable hydrogen-jet production in the ANKE pellet target. The experiments were performed at the test set-up of the pellet target in May 2001. Jet modifications in dependence of pressure deviations from the triple-point value ($\sim$ 100 mb) were studied.
A photo camera and a strobe light source were used to observe the jet inside the triple-point chamber (TPC), with equal frequencies of the light source and the droplet generator. The liquid hydrogen jet was produced with a nozzle of 60 μm diameter[1]. During our measurements the jet velocity was stabilized at a level of about 1 m/s. To fix the gas temperature inside the TPC, the temperature of the nozzle and the liquid hydrogen channel were measured and stabilized with an accuracy of about 10 mK. The temperatures were measured with silicon diode sensors DT-470 (Cryophysics). One sensor was mounted at the nozzle, a second one was placed on the generator flange. The gas pressures were measured at 12 points of the target system with APR260, TPR260, PKR250 sensors and MaxiGage controllers (PFEIFFER). To stabilize the gas pressure, MKS pressure and flow control systems 640A, 641A, 1359C, 647 were used. The stabilization of the hydrogen flow and pressure during our tests was not worse than 5%.
A stable hydrogen jet is generated in the target chamber only close to triple point conditions, T = 14 K and p = 100 mbar [1]. The jet is broken into droplets with the help of a sonic generator.
A pressure decrease to 85 mbar leads to unstable jet movements. The gas evaporation from the liquid surface increases and the skin of jet and droplets is cooled intensively. Thus, the jet position in the TPC is no longer stable and a part of the droplets freezes at the bottom of the TPC. If the pressure in the TPC is decreased further to 75 mbar, the surface of the jet is completely frozen, but a liquid jet is still moving inside the solid hydrogen. This process is shown in the upper photo of Fig. 1. Intuitively, this operation of the target has been called "macaroni mode".
The hydrogen jet freezes completely at a pressure of about 50 mbar and spontaneous growing of hydrogen icicles is observed. The onset of this process is shown in the lower photo.
The performed measurements and observations are very important for understanding of solid hydrogen pellet production processes from liquid droplets. These studies are progress at the ANKE pellet-target test setup.

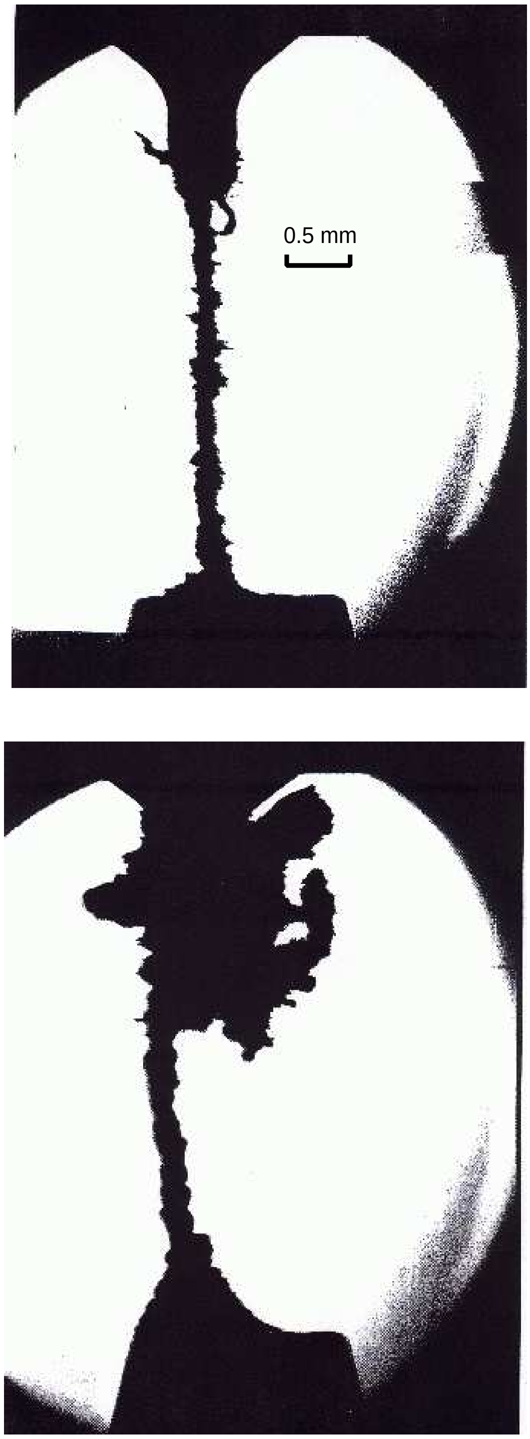

Fig. 1: Hydrogen-jet production in the TPC of the ANKE pellet target under different conditions. The surface of the hydrogen jet freezes at T = 14 K and p = 75 mbar (upper photo). At T = 14 K and p = 50 mbar spontaneous growing of hydrogen icicles is observed (lower).

References:

[1] V.Balanutsa et al., Contr. to this Ann.Rep., p.

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*Supported by grants: RFFI99-02-18179a, RFFI99-0204034, DFG-443RUS-113, WTZ-RUS-684-99, INTAS-98-500, ISTC#1966