Characterization of a croygenic adsorption valve for inert gases

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We are currently setting up ARTEMIS (AsymmetRic Trap for the measurement of Electron Magnetic moments in IonS) in the framework of the HITRAP facility. This experiment with highly charged ions in a cryogenic Penning trap combines precise spectroscopy both of optical transitions and microwave Zeeman splittings. The latter determine the magnetic magnetic moments (g factors) of bound electrons.

Argon ions are produced in the trap chamber by consecutive electron-impact ionization. To this end, neutral gas enters the trap chamber via a cryogenic valve and are bombarded with an electron beam coming from a field emission source.

The valve is depicted in Fig. 1: A narrow stainless steel tube comes from outside the outer vacuum chamber, which maintains a low pressure for the operation of the cryostat. We hook up a standard shutoff valve and a gas bottle on the lower end of the tube. The upper end is soldered to a cylindrical copper box, partially divided by several baffles. Another short tube guides the gas into the inner vacuum chamber, which will host the trap. The thermal contact to the trap chamber at 4 K via OFHC copper wire ensures a low temperature in the cold, i.e. 'closed', mode of the valve, while an attached resistor can locally heat it and regulate the temperature in the range of 15 to at least 100 K.

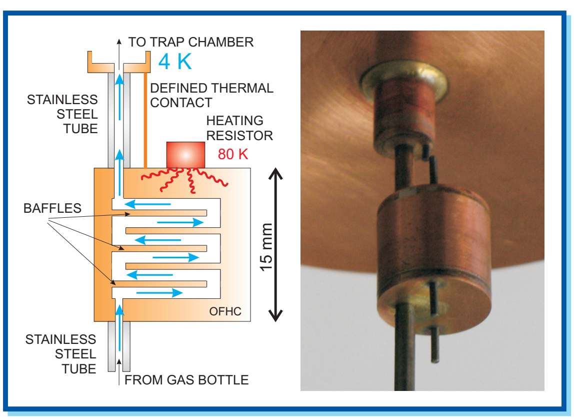

Figure 1: Schematic drawing of the adsorption valve with heater mounted, viewed in vertical section, and photograph of the ca. 1.5 cm long valve with tubes, soldered to the vacuum chamber.

The working principle relies on cryogenic adsorption: Atoms coming into the valve have to hit the baffles many times in order to travel through. They will most probably stick to a cold wall, so the box acts like a closed valve. When heated, sticking probability for incoming gas particles decreases, so that the valve is open. Additionally, the walls release adsorbed matter. Depending on the temperature, this allows a controlled flow of gas into the vacuum chamber [1, 2].

We have tested the valve with pulses of argon gas at defined pressure (1 mbar and below) and duration of 100 ms, applied at varying temperature. For the course of 10 s, the transmitted amount was recorded, using an IKR vacuum gauge as time-resolving detector inside the copper vacuum chamber, next to its gas port. It ranges down to 10^{-9} mbar.

The traces in Fig. 2 have been taken with 1.0 mbar pulse pressure, after several days of operation. No signal can be detected below 34 K. Above, a series of peaks appear. At increasing temperature they come with shorter delay and more intensity.

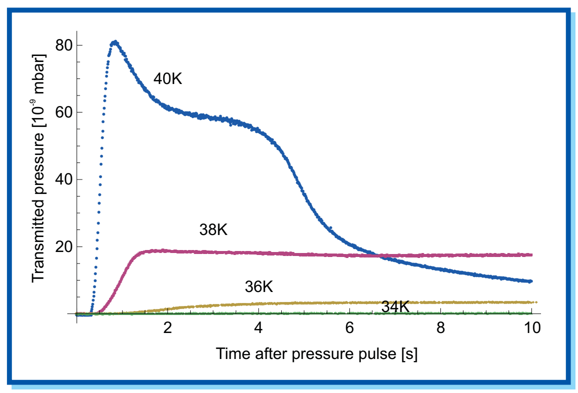

Figure 2: Time-resolved pressure in the vacuum chamber after the gas pulse, background corrected.

We are confident that the home-made gas valve will in the cold state maintain a pressure below 10^{-12} mbar in the vacuum chamber, mainly containing residual helium, hydrogen and neon gas, which are not cryo-pumped. When heated, it will supply enough argon for our measurement.

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References

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