Investigation of an Atomic Internal Lead Target for a Recycling Ring of Radioactive Ion Beams

V. Varentsov, H. J. Maier, and D. Habs

We explore the possibility to recycle radioactive ion beams in a storage ring with very large acceptance [1]. Due to the narrow width of reaction cross sections as a function of beam energy only thin targets can be used in single pass experiments. After resupplying the energy lost in the target the ion beam can be passed through the target $10^2 - 10^3$ times enhancing the yield. For the production of superheavy elements we need a lead target in the recycling ring with sufficient thickness, which tolerates the high beam intensity. We plan to use a recycling system with $6kg/h$ lead flow rate for the atomic lead target production. To study the properties of this internal vapor-jet target detailed computer simulations have been performed.

A heated rectangular converging-diverging super sonic nozzle (so called slit-nozzle) has been investigated for the production of a high thickness lead vapor-jet target with about $10^{17} atoms/cm^2$. To define an optimum nozzle geometry the computer simulations of the supersonic vapor-jet of atomic lead have been performed for different aspect ratios L/D (length and width of the nozzle throat), various values of the nozzle throat width D, different lengths and opening angles of the supersonic diverging part of the nozzle. Also the nozzle temperatures has been varied. As an example fig. 1 shows the density contours of the supersonic atomic lead jet expanding from the slit nozzle into a vacuum at an ambient pressure of $1 * 10^{-5} mbar$. The plot shows the plane that is parallel to the nozzle width of the short side of the slit-nozzle cross section. The flow direction is from left to right. The cross section of the nozzle throat is $0.8mm * 10mm$; the nozzle exit cross section is $8.8mm * 10mm$; the length of the nozzle supersonic part is $10mm$. The nozzle temperature was chosen to be $2022K$, which corresponds to the lead vapor stagnation pressure of $1bar$.

It is supposed that the atomic lead jet will be crossed by an ion beam at a few mm downstream the nozzle exit with the ion beam direction parallel to the nozzle length. This means that for a nozzle length $L = 10mm$ the target thickness in $atoms/cm^2$ will be numerically equal to the values of the jet density in $atoms/cm^3$ presented in fig.1.

For the numerical investigations of the lead vapor-jet target a new version of the VARJET computer code has been used. This code is described in detail in [2] and is based on the full time dependent system of Navier-Stokes equations for multicomponent gas mixtures. Coefficients of viscosity, heat conductivity, difussion as well as specific heat ratio are computed as a function of temperature using constants σ and ϵ of the Lenard-Jones interatomic potential. A steady flow pattern is calculated as a limit of an unsteady process with constant boundary conditions.

In the near future we first want to explore the recycling scheme for $6kg$ lead per hour in more detail. The experience with other metal jet targets looks promising.

References

[1] D. Habs *et al.*, Proc. 2nd Int. Conf. on Fission and Neutron-rich Nuclei, St. Andrews, Scotland, June 28 - July 2, 1999

[2] V. Varentsov. -etal, Nucl. Instr. Meth. **A413** (1998) 447

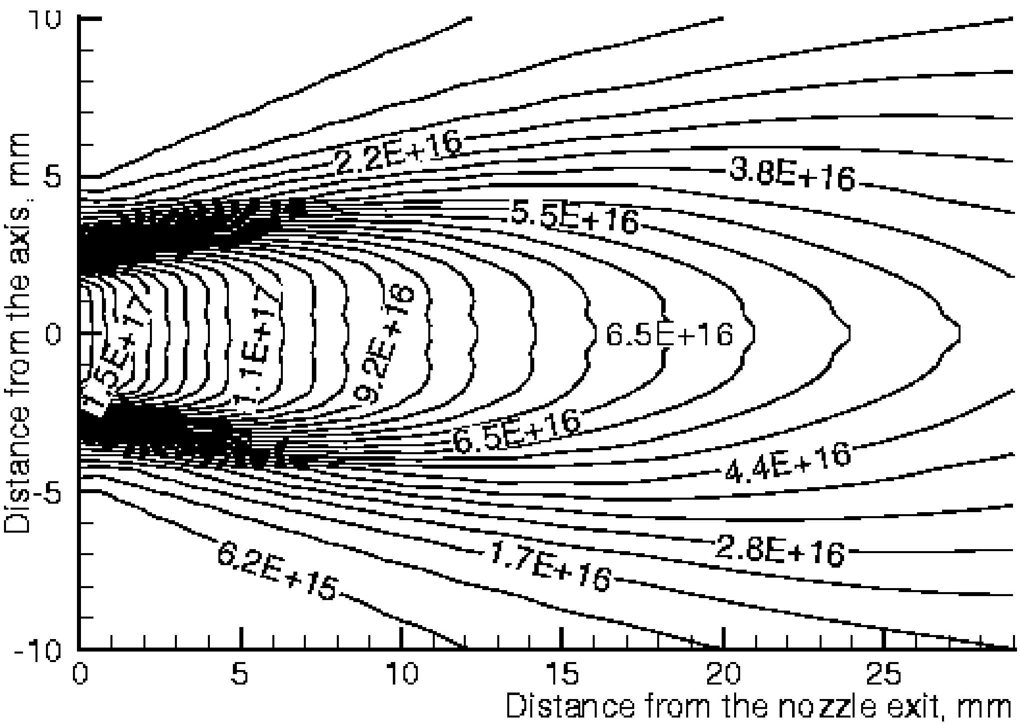

Fig. 1: Equidensity lines in $atoms/cm^3$ downstream the nozzle exit. The flow direction is from left to right.