Gas pressure influence on average charges of heavy recoils in TASCA

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Several experimental works at gas-filled separators have been reported that lay the basis for a correct prediction of the average charges of heavy and superheavy ions [1-3]. These works resulted in differing semi-empirical parameterizations.

An interesting feature of heavy ion "charge-exchange" collisions is the so-called “density effect”, which has been observed at the Dubna gas-filled recoil separator DGFRS [2]. However, such an influence of the gas pressure has never been included in any of the above-mentioned semi-empirical expressions. The effect was also observed at the gas-filled separator TASCA [4]. Here we report results for ^{252,254}No ions which were produced in the fusion-evaporation reactions ^{48}Ca+^{206,208}Pb.

The experimental setup and the reactions were the same as in [4]. Average charges and magnetic rigidities of No ions were deduced using the experimental distribution of evaporation residues in a focal plane detector [4]. The analysis method was the same as in [3].

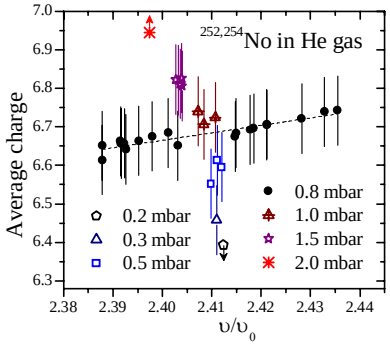

Figure 1: Measured average charges of the ^{252,254}No depending on their velocity (in units of the Bohr velocity). The line shows a linear fit. Arrows are marking limits for average charges.

Deduced average charges as a function of the velocity (expressed in units of the Bohr velocity, υ_0) are shown in Fig. 1. Average charges measured at 0.8 mbar gas pressure for both No ions (black solid dots) exhibit the linear dependence of the average charges on velocity. However, measured average charges at other pressures deviate significantly from this line. Deduced magnetic rigidities are shown in Fig. 2 for ^{252,254}No ions in helium (He) as well as for ^{254}No in hydrogen (H_2). These data show an increase of magnetic rigidities with decreasing pressure for both filling gases.

An expression to estimate the “density effect” has been given in [5] and we use it as a fit function for our experimental data. Average charges of heavy ions in a gas with pressure P can be presented as a sum of the equilibrated average charge and a correction term due to the "density effect", $q_{ion}=<q>+\Delta q$ [5]. Charge correction can be determined as as $\Delta q=a/(b+y)$ with $y=[(\upsilon/\upsilon_0)P]^{-1}$ in according to [5]. The function $(B\rho)_{ion}=(c+dy)/(f+y)$ can be used to fit measured magnetic rigidities, with c,d and f being parameters.

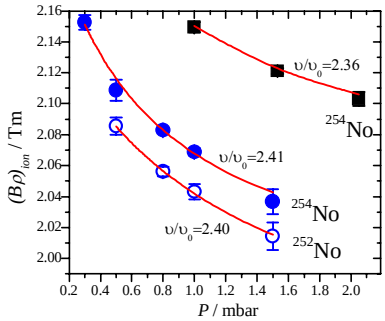

Figure 2: Magnetic rigidities of the ^{252,254}No ions as a function of the pressure. Circles and squares are denoting magnetic rigidities in He and H_2, respectively. Lines show fits to the data according to the relations given in the text.

Results of fits are shown in Fig. 2. The behavior of the fitted curves for both ^{252,254}No ions seems to be similar, as can be expected for ions with an identical atomic shell structure. The linear fit function $(B\rho)_{ion}= c+dy$ was used in the case of H_2 due to the limited number of experimental data points. These semi-empirical expressions which describe the “density effect” can be used as a correction for predicted average charges when using expressions from [1-3]. More detailed information will be provided in [6].

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