Energy Straggling of 60MeV ^{58}Ni Ions in Thin Carbon Foils and Gases

A. Bergmaier, G. Dollinger, C. M. Frey, S. Karsch, and O. Schmelmer

Energy straggling of 60MeV ^{58}Ni ions in thin carbon foils and gases in dependence on the incident and analysed charge state (q_{in} and q_{ana}) and the target thickness was measured in addition to the determined energy loss of these ions described in [1].

The FWHM of the measured energy distributions of the ions behind carbon foils for incident and analysed charge state $q_{in} = q_{ana} = 8$ and 18 are displayed in Fig. 1.

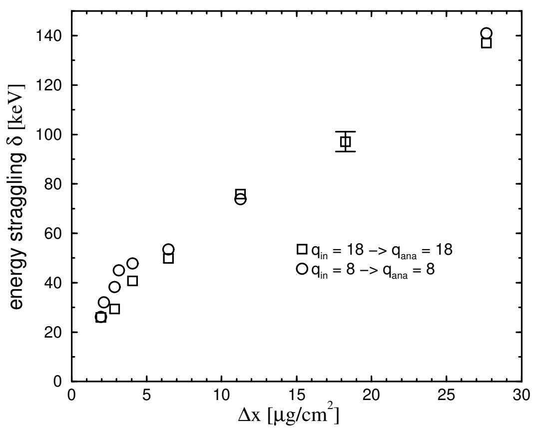

Fig. 1: Energy straggling of 60MeV ^{58}Ni ions in thin carbon foils for incident and analysed charge states $q_{in} = q_{ana} = 8$ and 18.

For carbon the energy straggling of ions with $q_{in} = 8$ and small target thickness ($\Delta x \leq 6\mu g/cm^2$) is bigger than the value of ions with $q_{in} = 18$ at the same target thickness. This shows the influence of charge changing events on energy straggling which occur dominantly at small target thicknesses. For larger thicknesses the energy straggling coincides for all measured charge states because the charge of the incident ion has reached the mean charge state $\bar{q}$ inside the target.

Fig. 2 shows the energy straggling of 60MeV ^{58}Ni ions in perfluorhexane, argon, deuterium and carbon versus the energy loss of the ions. In addition theoretical predictions of Bohr [2] and Hvelplund [3] are displayed. In the theory of Bohr Z_1 was replaced by Brandt's q_{eff} [4].

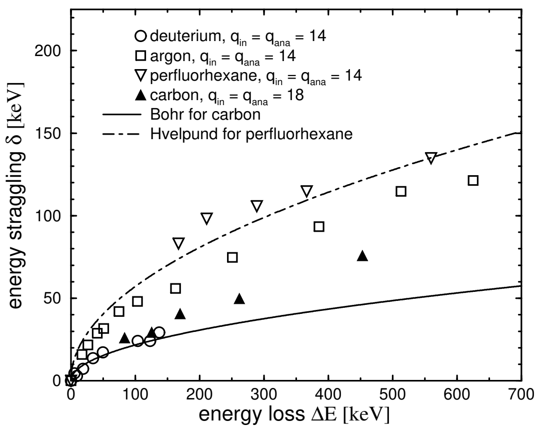

Fig. 2: Energy straggling of 60MeV ^{58}Ni ions in carbon foils and gases as a function of energy loss.

The chosen charge state of the ions in gases is close to the mean charge state $\bar{q}$ inside the target. The large energy straggling of ions in argon and perfluorhexane compared to Bohr theory indicates the influence of additional effects that contribute to the energy straggling of heavy ions in matter. One of the most important contribution are correlation effects which increase with the growing number of target electrons per gas molecule [5]. As Bohr's theory is based on a free electron gas model and light swift ions the deviations of the experiment are attributed to these correlations effects. Including these effects in straggling theory by Hvelplund the data are better reproduced. However, significant deviations are observed.

It was astonishing that the energy straggling of ions after their passage through carbon foils is lower than for multi electron gases and is nearly the same as for deuterium. Both can be reproduced by Bohr's theory, although the coincidence seems to be accidental.

References

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