Projectile Spectroscopy: Space Resolved Registration of Projectile X-Rays Inside Matter

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We report about the first successful observation of highly charged projectile radiation inside extended solid and gaseous matter at GSI. These investigations are of extraordinary interest for the physics of heavy ion beams interacting with matter because the x-ray spectra contain the information of the effective projectile charge state inside matter.

5.9 MeV/u Ni^{7+} with I = 100 pnA are interacting with Ar gas (p = 600-800 mbar). Figure 1 shows the X-ray emission of the K-shell spectra near λ = 0.16 nm of the multi charged Ni ions recorded in the 10th reflection order as well as the argon K_α transition in the 4 th reflection order of spherically bent mica crystals [1]. Spectra emitted from different distances clearly show a variation of the nickel charge states.

Similar type of experiments were conducted with 5.9 MeV/u Ar^{7+} projectiles with I = 100 pnA interacting with massive aerogel targets (SiO_2, ρ = 0.1 g/cm^{-3}, crystal lengths about 2 mm). The argon projectiles are stopped inside the crystal after about 1.3 mm. Space resolved high resolution Argon K-shell X-ray radiation near λ = 0.4 nm have been obtained in the 4th reflection order.

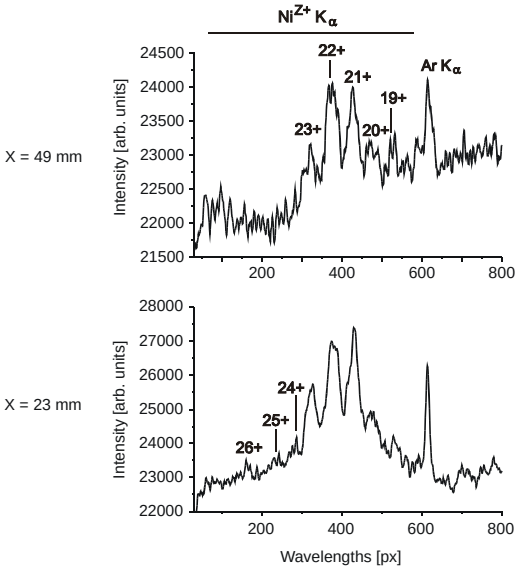

Figure 1: Space resolved X-ray spectra of Ni-projectiles

Figure 2 shows the characteristic K-shell emission of argon. The prominent spectral features are the H-like Ly_α lines $1s\ ^2S$ – $2p\ ^2P_{1/2,3/2}$, the He-like resonance line He_α = $1s2p\ ^1P_1$ – $1s^2\ ^1S_0$ and Al K_α (used as a reference line). The high quality of the space resolved spectra is easily demonstrated by the resolved Ly_α doublet (Fig. 2b). The set of figures (a-c) demonstrates the simultaneously achieved space resolution, however, due to the partial destruction of the SiO_2-target the definite relation to the target locations is not possible. The spectral features on the red wings of the H- and He-like resonance lines are identified as dielectronic satellite transitions, 2l2l' – 1s2l" and 1s2l2l' – $1s^22l$" respectively. Detailed investigation of the satellite group formation shows asymmetries to the red wavelengths side for both, the He-like and Li-like (see, e.g., the arrow in Fig. 2a) transitions. The origin of these kind of asymmetries has recently been explored for dense hot plasmas [2], [3]: hot electrons preferentially increase the inner-shell excitation channel. In the present experiments, this channel is driven by the fast argon ions colliding with the target molecules T=SiO_2.

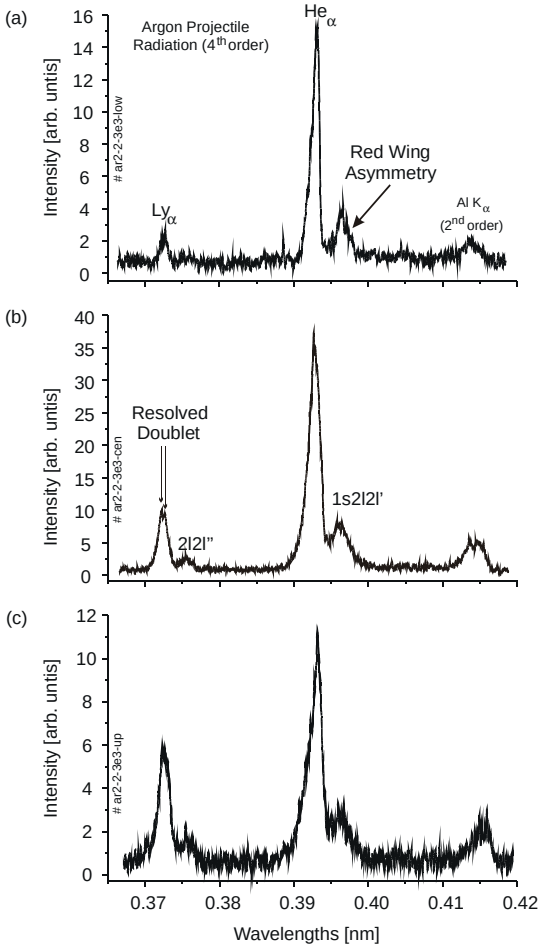

Figure 2: Space resolved X-ray spectra of H-, He- and Li-like argon projectiles emitted from the inner volume of an extended aerogel target

References

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