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A theoretical model for the soft protons scattering on X-ray optics.

The future X-ray mission ATHENA will orbit at the Lagrangian point L2, 1.5 million km far from Earth, an environment rich of charged particles. Among them, low energy protons (from a few keV to a hundred of keV), tagged as soft protons, will interact with the satellite, entering the mirrors, being reflected and focalized towards the focal plane detectors. Soft protons constitute a source of non X-ray background, which is difficult to identify and remove from scientific data, because the energy they deposit on the detectors can be mistakenly attributed to photons.

According to the scientific goals of the mission, the contribution of the soft protons component to the non X-ray background of ATHENA must be lower than 10% of the total, that converts on a rate of 5x10-4 cts/s/cm2/keV. Within this constrain, the knowledge of soft protons scattering at grazing incidence is crucial to have a correct estimate of the expected fluxes at the focal plane.

The physics of the interaction of soft protons with X-ray mirrors is nowadays still poorly understood, also due to a lack of experimental measurements. The few available experimental data (Diebold et al., 2015, and Diebold et al., 2017) concerns soft protons scattering on eRosita optics, coated with gold. A first comparison of the data from 2015 with several physical models has been already made by Fioretti et al. (2016), using Geant4 simulations. However, none of the models they used is in total agreement with the data, being the energy losses lower than expected and the peaks of the simulated distributions higher than the experimental ones.

In our work, we compare all the experimental data with the model given by Remizovich et al. (1980) in non-elastic approximation. According to this model, the scattering efficiencies depend, among the others, on a parameter σ, which is proportional to the ratio of the mean-square of the scattering angles that a particle experiences as interacts with matter to the square of the glancing angle.

We fit the experimental data to determine the values of σ, successfully reproducing for the first time both the scattering efficiencies and the energy losses. We also derived the trend of the parameter σ as a function of the angle and of the energy of the incident beam.