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X-ray emission study performed for H-like lead at the electron cooler of CRYRING@ESR

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The study of x-ray emission associated with Radiative Recombination (RR) at "cold"temperature conditions, as it prevails at electron cooler devices at ion storage rings, allows for a stringent test of atomic structure and the subsequent x-ray emission characteristics. In particular, for heavy, highly charged ions at high-Z it enables to investigate in detail the prevailing cascade decay dynamics and provides detailed insight into the final state population of the recombination process itself. We report on an experiment where bare lead ions were decelerated down to 10 MeV/u in the ESR storage ring at GSI, Darmstadt and injected into CRYRING@ESR and, subsequently, the x-ray emission of H-like lead associated with RR were studied at the electron cooler. For this purpose, at the electron cooler dedicated vacuum chambers were used, equipped with beryllium view ports allowing for x-ray detection under 0° and 180° with respect to the ion beam axis. The x-ray detection was accomplished by using two standard high-purity germanium x-ray detectors. In order to suppress the dominant background, stemming from x-ray emission by the electron beam (bremsstrahlung) and the natural background, an ion detector (channel electron multiplier) was operated downstream to the cooler, enabling to record x-rays in coincidence with down-charged Pb81+ ions from electron cooler section. In this experiment, we observed for the very first time for stored ions the full x-ray emission spectrum associated with RR under electron cooling conditions. Most remarkably, no line distortion effect due to delayed emission are present in the well resolved spectra, spanning over a wide range of x-ray energies (from about 5 to 100 keV) which enable to identify fine-structure resolved Lyman, Balmer as well as Paschen x-ray lines along with the RR transitions into the K-, L- and M-shell of the ions. To compare with theory, an elaborate theoretical model has been applied. By considering the relativistic atomic structure of Pb81+, this model is based on a sophisticated computation of the initial population distribution via RR for all atomic levels up to Rydberg states with principal quantum number n = 165 in combination with cascade calculations based on time-dependent rate equations. Most notably, this comparison sheds light on the contribution of prompt and delayed x-ray emission to the observed x-ray spectra, originating in particular from Yrast transitions into inner shells.

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