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(G*) Bound-state beta-decay of Thallium-205 for low-energy neutrino flux

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Bound-state beta-decay (β_b^--decay) is an exotic β^--decay mode where the electron is emitted directly into a bound orbital of the daughter nuclei. The electron is emitted into the K- or L-orbitals so this decay mode is only possible for highly charged ions. The first experimental confirmation of β_b^--decay was achieved 30 years ago at the Experimental Storage Ring (ESR) at GSI Darmstadt. Thallium-205 as a neutral atom is stable but the bare ion $^{205}Tl^{81+}$ is unstable to β_b^--decay, so removing all electrons from ^{205}Tl literally changes its stability. The capture of solar-neutrinos onto ^{205}Tl to produce ^{205}Pb is the lowest energy threshold neutrino-induced reaction known at just 53 keV, allowing us to probe a completely new region of the solar-neutrino spectrum. The LORandite EXperiment (LOREX) aims to extract a time-averaged flux measurement from the thallium-bearing mineral Lorandite ($TlAsS_2$) by determining the ^{205}Pb content of the mineral deposit. However, the neutrino-capture reaction rate is highly uncertain because the nuclear matrix element (which is identical to the β-decay matrix element) is unknown as neutral ^{205}Tl is stable. The measurement of the β_b^--decay half-life, and hence the β-decay matrix element, is crucial for the LOREX experiment to succeed.

The β_b^--decay measurement of $^{205}Tl^{81+}$ was conducted at the GSI Heavy Ion Facility in March 2020. A ^{206}Pb primary was impacted onto a beryllium target to produce a $^{205}Tl^{81+}$ beam at 400 MeV/u that was stored in the Experimental Storage Ring. During storage, the beam is electron cooled and monitored by resonant Schottky detectors that identify ion species and intensity by their revolution frequency in the ring. An Argon gas target was used to remove the bound electron from the $^{205}Pb^{81+}$ daughter ions so they could be counted. The $^{205}Tl^{81+}$ injections were stored for a variety of times, and the growth of the $^{205}Pb^{82+}$ signal was directly attributable to β_b^--decay. From the linear growth over time, the decay rate was calculated. The authors aim to present the motivation, storage ring methods, and some preliminary results.

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