



Contribution ID: 143

Type: **Invited**

## Nuclear physics in the $N \sim 126$ region relevant to the r process

Monday 5 September 2022 10:00 (30 minutes)

Half of the nuclei heavier than iron were synthesized in the r process. The r-process yield peak at  $A \sim 195$  is linked to the  $N=126$  closed neutron shell. In contrast to lighter mass regions, the r-process waiting point nuclei at  $N=126$  still cannot be studied experimentally, and the yield calculations rely entirely on theoretical nuclear physics properties.

The most neutron rich  $N=126$  nuclei for which basic observables such as the ground-state lifetime and mass were determined are  $^{204}\text{Pt}$  ( $Z=78$ ) and  $^{206}\text{Hg}$  ( $Z=80$ ), respectively. Therefore information on features which determine these values, single-particle energies and nucleon-nucleon interactions are crucial in order to increase the predictive power of nuclear theories. Nuclear structure information, like excited state energies, gamma-ray transition energies and transition strength are known “down” to  $^{203}\text{Ir}$  ( $Z=77$ ).

In the case of the beta decay of  $N \sim 126$  nuclei there is a strong competition between allowed and first-forbidden transitions. First-forbidden (FF) transitions can be dominant, with profound implications on their half-lives and therefore on the r-process [1]. And FF transitions are notoriously difficult to calculate. The beta decay of  $^{208}\text{Hg}$  into  $^{208}\text{Tl}$  was studied at ISOLDE Decay Station at CERN. Three negative parity excited states in  $^{208}\text{Tl}$  were populated directly in beta decay. In contrast none of the positive parity states were populated. This latter can be understood by considering the properties of the single proton and neutrons involved [2]. Similarly to  $^{208}\text{Hg}$ ,  $^{207}\text{Hg}$  also decays predominantly via first-forbidden decays [3]. In addition, the validity of the less known  $\Delta n=0$  selection rule in Gamow-Teller beta decay was investigated [4]. This selection rule has little importance for nuclei close to stability, but is essential for the  $Z < 82$ ,  $N > 126$  r-process waiting point nuclei, lengthening their lifetimes. Furthermore, accelerated radioactive beams at HIE-ISOLDE allowed for the first exploration of proton states beyond the  $N=126$  closed shell [5], and the measurement of the transition strength  $B(E2; 2^{+-} \rightarrow 0^+)$  transition strength in  $^{206}\text{Hg}$  [6].

In conclusion, the status of nuclear physics knowledge in the  $N \sim 126$  region relevant to the r-process will be presented. Future opportunities will be also discussed.

[1] N. Nishimura, Zs. Podolyák, D.-L. Fang, T. Suzuki, Phys. Lett. B 756, 273 (2016).

[2] R.J. Carrol et al., Phys. Rev. Lett. 125, 192501 (2020).

[3] T.A. Berry et al., Phys. Rev. C. 101, 054311 (2020).

[4] T.A. Berry et al., Phys. Lett. B793, 271 (2019).

[5] T.L. Tang et al, Phys. Rev. Lett. 124, 062502 (2020).

[6] L. Morrison et al., to be published.

### Field of work

**Author:** PODOLYAK, Zsolt

**Presenter:** PODOLYAK, Zsolt

**Session Classification:** Monday - Session 1