Study of 11/2$^-$ isomer in neutron-rich N = 126 nucleus ^{203}Ir
PRISMA + AGATA

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I. SCIENTIFIC MOTIVATION

As the heaviest sphere doubly magic nucleus so far, the south vicinity of ^{208}Pb (Z = 82, N = 126) attracts particular interest not only in the purely shell structure perspective but also in its strong astrophysical implications, especially in improving our understanding of the A = 195 peak of the solar r-process abundance distribution [Mu16]. Experimental studies have shown that the N = 126 remains robust in even-Z isotopes till Pt(Z = 78) isotopes as shown in Fig. 1.

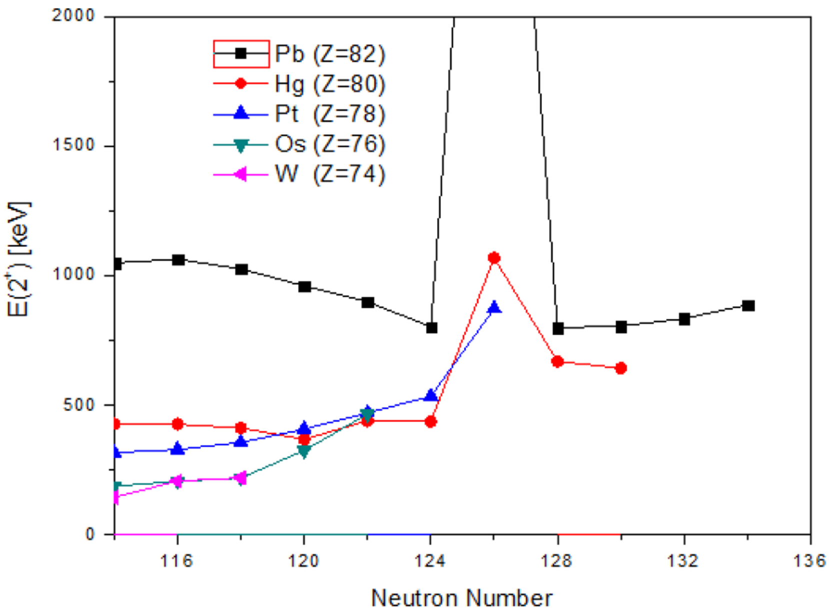

FIG. 1: Systematics of E(2_1^+) in even-Z isotopes below ^{208}Pb

For the odd-Z, even-N nuclei below the ^{208}Pb, they typically have 3/2$^+$ or 1/2$^+$ ground states and 11/2$^-$ isomeric states, corresponding to a proton hole in 2$d_{3/2}$, 3$s_{1/2}$, or 1$h_{11/2}$ shells, respectively. The excitation energies of the 11/2$^-$ isomeric states toward the closed neutron shell at N =126 can provide invaluable insight on the evolution of proton subshell structure, as well as the N = 126 closed shells due to the mutual influence between neutron and proton shells.

To illustrate how the Z = 76 subshell gap evolves in odd-Z isotopes below ^{208}Pb, the available experimental energy differences between the lowest 11/2$^-$ and 3/2$^+$ states are summarized for odd-A Tl(Z = 81), Au(Z = 79), Ir(Z = 77), and Re(Z = 75) isotopes in Fig. 2. For the Tl isotopes, although the systematics of the energy spacing have some fluctuations, they remain generally flat, manifesting the stability of both Z = 76 and N = 126 shell gaps in Tl isotopes. For the Au isotopes, with the increase of the neutron number, this energy difference increases smoothly and reaches the maximum at N = 126, which is close to the value in Tl isotope. Such pattern suggests the stability of Z = 76 at N = 126 for Au isotopes. So far, the experimental information of 11/2$^-$ states in neutron-rich Ir and Re is very scarce. Therefore, it is very interesting to see how the 11/2$^-$ state will evolve with respect to the 3/2$^+$ state in the lighter-Z Ir and Re isotopes when approaching N =126: Will it increase to the similar values as Tl and Au isotopes or remain small value?

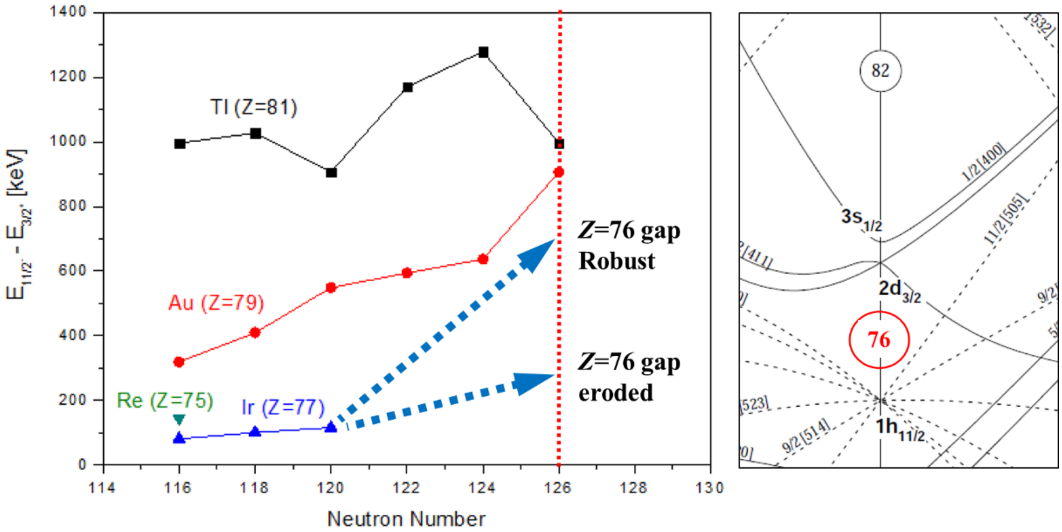

FIG. 2: (Left) Systematics of experimental energy differences between the lowest-lying $11/2^-$ and $3/2^+$ states in odd-A Tl, Au, Ir, and Re isotopes; (Right) Nilsson diagram for protons.

II. PROPOSED EXPERIMENT

In this proposal, we plan to study the $11/2^-$ isomer in neutron-rich N = 126 nucleus ^{203}Ir (Z = 77, N = 126), which is expected to decays both internally and via β decay [Li25]. So far, a tentative $23/2^+$ spin-parity of the isomer with half-live of 0.80(35) μs in ^{203}Ir was reported [St11], which was suggested to decay to the $11/2^-$ isomer but nothing is known experimentally about the excitation energy of this $11/2^-$ isomer. We propose to produce the ^{203}Ir through ^{238}U + ^{198}Pt multi-nucleon transfer reaction (MNT). The MNT has shown significant cross-section for the production of the heavy neutron-rich isotopes around N = 126 [Sa20, Wa15]. An implantation and decayed electron detection system, which was developed at Peking University [He14], will be installed at the PRISMA focal plane. It will stop the ^{203}Ir nucleus and measure the subsequent internal conversion electron from the decay of $11/2^-$ isomer in ^{203}Ir within the same pixel or adjacent pixels of a double-sided silicon detector (DSSD).

The goals of the experiment are: a) To determine the excitation energy of $11/2^-$ isomer in ^{203}Ir via the measurement of internal conversion electron. b) To identified the excited states above the $11/2^-$ isomer via the measurement of γ transitions with AGATA.

III. RATE ESTIMATES AND BEAM TIME REQUEST

Estimates of the expected rates are required. The beam time request should specify:

- beam: ^{238}U, 1 pnA, 6.5 MeV/nucleon, continuous
- target: ^{198}Pt, 1 mg/cm^2, no backing
- experimental setup: PRISMA + AGATA
- beam time: 7 days

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[St11] S.J. Steer, Zs. Podolyak, S. Pietri et al., Phys. Rev. C 84, 044313 (2011).

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